U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 86.
L. O. HOWARD, Entomologist and Chief of Bureau.

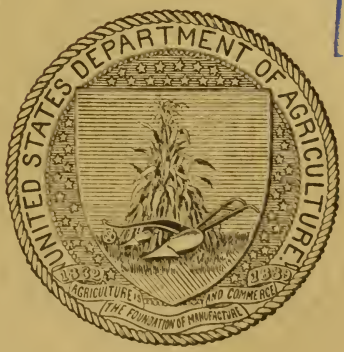
PLANT-BUGS INJURIOUS TO COTTON BOLLS.

BY

A. W. MORRILL, PH. D.,

Entomologist of the Arizona Horticultural Commission and of the Arizona Agricultural Experiment Station.

ISSUED JUNE 14, 1910.



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1910.

SOME OF THE MORE IMPORTANT PLANT-BUGS WHICH ATTACK COTTON BOLLS.

Fig. 1.—The conchuela (*Pentatoma ligata*). Fig. 2.—The brown cotton-bug (*Euschistus servus*). Fig. 3.—The green soldier-bug (*Nezara hilaris*). Fig. 4.—*Thyanta custator*. Fig. 5.—*Acanthocephala femorata*. Fig. 6.—The leaf-footed plant-bug (*Leptoglossus phyllopus*). Fig. 7.—The bordered plant-bug (*Largus succinctus*). Fig. 8.—The cotton stainer (*Dysdercus suturellus*). Fig. 9.—*Oncopeltus fasciatus*, showing egg of Tachinid parasite attached to upper side of head between the eyes. All enlarged one-third. (Original.)

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., December 13, 1909.

Sir: I have the honor to transmit herewith for publication a manuscript entitled "Plant-bugs Injurious to Cotton Bolls," by Dr. A. W. Morrill, entomologist of the Arizona Horticultural Commission and of the Arizona Agricultural Experiment Station, Phoenix, Ariz.

The work upon which this manuscript is largely based was conducted by Doctor Morrill and this report prepared and submitted by him while he was a special field agent of this Bureau. It grew out of an investigation of the so-called "conchuela" of northern Mexico, a plant-bug which has proved to be especially destructive to cotton bolls. The same insect pest was studied further in western Texas, and other species were investigated both there and in other sections of the United States.

Although the injury to the cotton crop effected by plant-bugs is of course secondary to that caused by the boll weevil, yet it is by no means inconsiderable and renders necessary a knowledge of the life histories of these injurious bugs and of the best methods for their control. I would therefore recommend the publication of this manuscript as Bulletin No. 86 of the Bureau of Entomology.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

Damage by the boll weevil has brought into prominence many other insects which attack the cotton plant, the work of which has been largely overlooked. Among the most important of these minor insects are various species of plant-bugs. Many of these have been known as enemies of the cotton plant for some years, but they have received only slight attention from economic entomologists. When their damage is added to the injury done by the cotton boll weevil, still further reducing the crop, they become of such importance that full knowledge of their habits and life history is demanded. The studies upon which this bulletin is based were conducted to add to our knowledge of the biology of an important group of insect pests and of the most practical and efficient methods by which they may be controlled.

The plant-bugs with which this bulletin deals, in addition to destroying many cotton bolls and squares, cause more or less staining of the fiber, thus reducing the quality. A large portion of the so-called "spotted cotton," which everywhere suffers a considerable reduction in price below unspotted cotton, is due to the work of plant-bugs. The damage is not confined to any restricted areas, though different species of bugs occur in different parts of the cotton belt. Therefore the damage that is done by these insect pests every year is by no means inconsiderable.

The work accomplished by Doctor Morrill and reported on in this bulletin grew out of an investigation of the Mexican conchuela (*Pentatoma ligata* Say) in northern Mexico. An opportunity was there afforded for a rather careful study of the life history and habits of a representative of the large family of plant-bugs. This was followed by investigations of the same species in western Texas and of other species in other localities. As a result Doctor Morrill's work gives rather complete knowledge of insects the work of which will assume new importance as the area of boll-weevil infestation continues to increase in the United States.

For valuable notes and data on various subjects concerning the conchuela, and especially on its seasonal history, for hearty cooperation in experimental work, and for the facilities which aided in

conducting field observations, much credit is due Mr. J. P. Conduit and Mr. J. A. Vaughan, of the Tlahualilo Agricultural Company, Tlahualilo, Durango, Mexico. Mr. B. F. Butler of the same company, manager of the Hacienda San Fernando, Lerdo, Durango, Mexico, furnished valuable information concerning the comparative grading of the cotton staple at infested and uninfested sections of the Laguna district. All of the investigations reported in this paper were conducted by Doctor Morrill, except where special credit has been given in the text. Of the original text figures, numbers 2, 3, 4, 5, 6, 10, 11, 15, 16, 17, and 18 were drawn by Mr. J. F. Strauss, of this Bureau, while the remainder are the work of the author.

W. D. Hunter,
In Charge of Southern Field Crop Insect Investigations.

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HISTORICAL REVIEW OF PUBLISHED WRITINGS ON PLANT-BUGS INJURIOUS TO COTTON BOLLS.

For reasons hereinafter explained, comparatively little has been written concerning insects of the suborder Heteroptera (better known as plant-bugs) in relation to their damage to cotton. The earliest records of this kind are found in the writings of Townend Glover. In the U. S. Agricultural Report for 1854,[a] in a short article on insects infesting the cotton plant, Glover writes: "Several insects (Pentatoma and Anisoscelis) were very abundant in the cotton fields, both on the bolls and leaves, which have been accused of piercing the young bolls for the sake of the juice, but as none were observed in the act it can not be stated definitely whether they actually do harm or not, before their habits have received further investigation." In the report published for the following year (1855)[b] the same writer gives a brief account of many insects which frequent the cotton plant, and refers to the rotting of bolls as possibly due to the feeding of plant-bugs, mentioning especially two Pentatomids, one apparently *Nezara hilaris* Say, and the other apparently of the genus *Euschistus*, as also a Coreid, which, judging from the description and drawing, is *Leptoglossus phyllopus* L. The cotton leaf-bug (*Calocoris rapidus* Say), which in 1903 and 1904 proved to be of considerable importance as a cotton pest in certain sections of Texas, was here first recorded in this connection and nearly two pages in this report were devoted to the well-known "red bug" or cotton stainer (*Dysdercus suturellus* H. Schf.), an account being given of its occurrence and depredations on cotton in Florida. The report for the year 1858[c] contains additional notes on this latter pest. No writings concerning Heteropterous insects attacking cotton bolls, published between the date of this last-mentioned report and that for the year 1875, are known to the writer. In Glover's report for 1875[d] the cotton

[a] Agricultural Report for 1854, p. 61.

[b] Agricultural Report for 1855, pp. 86–87, 93–95, 103–105.

[c] Agricultural Report for 1858, pp. 271–273.

[d] Report of Commissioner of Agriculture for 1875, p. 124.

stainer is again referred to. The same author in 1878[a] figures and mentions certain Heteroptera found on cotton, including *Nezara pennsylvanica* De Geer, *Euschistus punctipes* Say, and *Leptoglossus phyllopus* L. Professor Comstock, in his report for 1879,[b] reviews what was then known about the cotton stainer and gives an account of its first appearance as an orange pest, stating that the principal injury to this fruit was done where cotton was planted in close proximity to the orange groves. In Professor Comstock's Report on Cotton Insects,[c] published in 1879, the green soldier-bug (*Nezara hilaris*) is credited with being more or less beneficial in cotton fields, owing to its reported destruction of cotton worms. The report of Mr. E. A. Schwarz of the destruction of cotton in the Bahamas by *Dysdercus suturellus* as observed by him in 1879[d] is of special interest on account of his description of the injury caused by this insect, and will be referred to again in discussing the nature of the injury caused by Heteropterous pests. In 1889 Riley and Howard[e] gave the most complete account of the cotton stainer that has been published. Insect Life, in 1890,[f] contains a brief note to the effect that a correspondent of the Division of Entomology had sent in specimens of the green soldier-bug (*Nezara hilaris*), reporting that they were damaging cotton in Florida. Mr. F. W. Mally, in 1893,[g] in his report on the bollworm of cotton briefly described injury to cotton by *Calocoris rapidus* and *Largus cinctus* H. Schf. In a paper entitled "Notes on cotton insects found in Mississippi," published in 1895,[h] the late Dr. Wm. H. Ashmead gave brief notes on a number of Heteroptera which he had collected on cotton, including several actually observed feeding on the boll. A report of damage to cotton in Peru by one of the cotton stainers (*Dysdercus ruficollis*) was noted by Dr. L. O. Howard in 1900,[i] in a Miscellaneous Results bulletin of this office, and a similar report of damage by the St. Andrews cotton stainer in Cuba was noted by Mr. W. D. Hunter,[j] in a bulletin of the same series published in 1902. Extensive damage to cotton in Mexico in 1903 by the Pentatomid bug known as the conchuela (*Pentatoma ligata* Say) led the following year to a preliminary investigation of this pest, which was reported by the author in a previous bulletin of this

[a] Manuscript Notes from My Journal, Pl. XVI.
[b] Report of Commissioner of Agriculture for 1879, pp. 203–204.
[c] Report on Cotton Insects, p. 167.
[d] Report on Cotton Insects, pp. 348–349.
[e] Insect Life, Vol. I, pp. 234–241.
[f] Insect Life, Vol. III, p. 403.
[g] Bul. 29, Div. Ent., U. S. Dept. Agr., p. 31.
[h] Insect Life, Vol. VII, pp. 320–321.
[i] Bul. 22, Div. Ent., U. S. Dept. Agr., p. 100.
[j] Bul. 38, Div. Ent., U. S. Dept. Agr., p. 106.

Bureau.[a] Prof. E. D. Sanderson during the same year conducted observations on miscellaneous cotton insects in Texas, including several of the Heteroptera. The results of his work on this subject have been incorporated in a Farmers' Bulletin of the Department of Agriculture[b] and in a regular bulletin of this Bureau.[c] Plant-bugs attacking cotton in the Bismarck Archipelago and in German East Africa have been considered by Dr. Th. Kuhlgatz in a publication of the Berlin Zoological Museum in 1905.[d] This report contains but few field notes outside of records of food plants. A valuable report on cotton stainers in the West Indies was published by Mr. H. A. Ballou in 1906.[e]

GENERAL CONSIDERATIONS.

NATURE OF INJURY BY PLANT-BUGS.

In beginning the investigation of plant-bugs destructive to the cotton boll one of the first steps found to be necessary was a study of the nature of the injury itself so that it might be identified positively or at least with reasonable certainty. As a result it has been more and more impressed upon the author that to the lack of an accurate knowledge of this subject is due the almost complete ignoring of these insects as cotton pests. In general the connection between the insects and the damage which results from their attacks is very obscure to the casual observer, and consequently seldom suspected. Even to an entomologist the damaged boll when dry gives by itself no direct evidence of the cause of its condition without reference to a field demonstration of the relation between the insects and the stained or shriveled locks.

PUBLISHED DESCRIPTIONS OF THE EFFECT OF PLANT-BUG ATTACK ON COTTON BOLLS.

In Glover's brief publication on this subject in the U. S. Agricultural Report for the year 1855 is to be found the earliest mention of plant-bugs—Pentatomids and Coreids—as possible producers of "rot" in cotton bolls and also of the nature of injury by the cotton stainer. This discussion, of the damage to cotton caused by the Coreidæ, is the most complete that has been published, and in fact all later references to the subject are based directly or indirectly upon this except the report of Mr. Schwarz's observations in the Bahamas and the recent report by Mr. Ballou. Heretofore it seems to have been the popular belief in Florida that the principal damage to the

[a] Bul. 54, Bur. Ent., U. S. Dept. Agr., pp. 18–34.

[b] Farmers' Bul. 223, U. S. Dept. Agr., pp. 20–21.

[c] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 44–49.

[d] Mittheilungen aus dem Zoologischen Museum in Berlin, III Band, 1 heft, pp. 31–114.

[e] West Indian Bulletin, Vol. VII, No. 1, pp. 64–85.

cotton was through the staining of lint in the open bolls by the excrement of these insects. In this connection it seems well to refer to the common belief among the natives of that part of Mexico where the conchuela has been so destructive, that the damage to the cotton is effected by the voiding of excrement upon the lint and unopened bolls. The author can state positively that such a belief is unfounded in this instance, and that he is, moreover, disposed to look carefully into the source of all such similar suppositions before accepting them as entirely credible. Glover quotes at length a communication from a Sea Island cotton grower in Florida who shows himself to be a careful observer, capable of distinguishing between fact and theory. This correspondent states: "The pod or boll is perforated by the bug. Whether the staining matter is imparted to the fiber of the cotton during the perforation directly or by a slow process diffusing itself with the sap abounding at the time in the pod is not yet ascertained. I am of the latter opinion, *from the fact that almost the entire product of the boll is discolored when it opens*, which does not seem at all to cause a premature development."[a] As opposed to this source of the discoloration Glover merely states: "It has been stated by other planters that the fæces of the insect produce the reddish or greenish stain." Three years later the same author states[b] concerning the injury by the cotton stainer: "It drains the sap from the bolls by its puncture, causing them to become diminutive or abortive, but the principal injury it does is by sucking the juice of the seed and boll and then voiding an excrementitious liquid, which stains the cotton fiber yellow or reddish, and very much depreciates its value in the market, the stains being indelible." This description of the injury, as well as the descriptions presented in the later writings of Glover and others on the cotton stainer in Florida, seems to be based on the first account of the insect damage from which the above quotations were made. In 1879 Mr. E. A. Schwarz,[c] in a report on insects injuring cotton in the Bahamas, refers to the cotton stainer of the Bahamas, later identified as belonging to the same species which occurs in this country. He states regarding its injury: "It punctures the green bolls, thus preventing them from opening; the bolls wilt and finally dry up, the half-formed cotton and dried-up seeds giving food to a number of other insects; more often the cotton-bug crowds in the half or not quite half open bolls, sucking the seeds, thus preventing the cotton from blowing, or at least renders the cotton yellow and unfit for use." As these observations extended over a period of less than ten days, they do not disprove the statements of Glover's

[a] Italics are mine.—A. W. M.

[b] Agricultural Report, 1858.

[c] Report upon Cotton Insects, pp. 347–349.

correspondent that the discoloration appears as soon as the boll opens.

Following the foregoing accounts the next reference to the nature of plant-bug damage, so far as known to the writer, is a brief description of damage to cotton in Egypt by a Lygæid, *Oxycarenus hyalinipennis* Costa, published in 1890.[a] This description, which is credited to Dr. E. Sickenberger, states that these insects "suck the sap from the base of the young pods and from the blossoms and thus prevent their development; they attack also the seeds when they are tender, which results in a diminution of the germinative strength and consequently a diminution in the product of the plant." A staining of the lint is also mentioned but the exact method by which this injury is brought about is unexplained.

The cotton leaf-bug (*Calocoris rapidus* Say) and the bordered plant-bug (*Largus succinctus* L.) are reported by Mr. F. W. Mally[b] to damage cotton bolls, leaving a small, round, black dot at the point of the puncture. He says: "The injury nearly always has the effect of causing the boll to '*flare*' and drop, or if not, then the tuft of cotton in that section of the boll becomes stained." The first accounts of damage to cotton bolls, with Heteropterous insects determined as the cause by definite experimental work, were published in 1905, Prof. E. D. Sanderson describing the injury caused by *Calocoris rapidus*, and the present writer the injury by the conchuela, *Pentatoma ligata* Say. Concerning the former Professor Sanderson[c] says: "It punctured the squares and young bolls, either causing them to drop or making the bolls shrivel or decay where punctured. The punctures in the boll are indicated by small round black spots resembling diseased places, which gradually become larger and sunken." The fullest consideration heretofore published of the nature of the injury caused by the cotton stainers is found in the recent paper by Mr. H. A. Ballou, previously referred to. This author reports no personal observations concerning the staining of cotton lint by the excrement of the bugs but mentions the probability of injury through the feeding of the insects on immature bolls and, later, on the seed at time of the opening of the bolls.

EXTERNAL EVIDENCE OF PLANT-BUG INJURY.

As the leaf-bug (*Calocoris rapidus*) is sometimes present in considerable numbers in cotton fields where no external evidence of injury such as described by Professor Sanderson can be found, it seems likely that the sunken spots on the outside of the boll, resembling some diseased condition, are not a necessary accompaniment of

[a] Insect Life, Vol. III, p. 68, 1890.

[b] Bul. 29, o. s., Div. Ent., U. S. Dept. Agr., p. 31, 1893.

[c] Farmers' Bulletin 223, p. 20, 1905.

this insect-damage (Pl. II, fig. 5). However, the fact that they have been produced in some cases differentiates the injury by this Capsid from that of all Pentatomids, Coreids, and Pyrrhocorids which has come under the writer's observation. Investigations during the past two years in many sections of Texas and in northern Mexico with representatives of these three last-mentioned families of Heteroptera have failed to show a direct connection between spots of any kind on the outside of the carpels of the injured bolls and the insect's punctures. In nearly all cotton fields bolls can be found which are marked with reddish or brownish spots (Pl. II, fig. 8), more frequently seen on the parts of the boll not covered by bracts, and never showing on the inside of the carpels. It is apparently an evidence of a physiological disorder of little or no consequence, but in some cases these spots have appeared to bear a relationship to the condition of the developing lock. To determine if any such relationship existed in the case of green bolls damaged by plant-bugs, 100 bolls were examined, with the following results:

Average number of spots in 25 bolls with slightly stained locks	2.24
Average number of spots in 75 bolls with badly stained locks	3
Percentage of badly stained bolls without spots	10
Percentage of slightly stained bolls without spots	46

A second lot of green bolls picked from plants on July 11, 1905, was examined and the results are here presented in tabular form.

TABLE I.—*Relation of external spots to plant-bug injury of cotton bolls.*

Number of external spots.	Number of bolls.	Number of bolls damaged.	Number of bolls uninjured.
More than one	17	17	0
One	11	9	2
None	10	7	3
Total	38	33	5

The punctures may be through the spot, but this is entirely accidental. One boll of the above lot showing over 60 conchuela punctures was found to have but three small external spots, while the carpel of the lock most severely damaged was entirely free from discoloration. Among those examined which showed but one external spot, several were as badly damaged as any of the entire number. From the foregoing observations we may conclude that the spots here referred to with which every cotton grower is familiar do not bear a direct relation to punctures by plant-bugs, for the spots may be present on bolls which show no punctures, which in all cases are detectable when present as hereafter described, and may be absent on badly damaged bolls. They are shown, however, to have a secondary

EFFECTS OF PLANT-BUG ATTACK ON COTTON BOLLS.

Fig. 1.—Boll with section of carpel removed to show plant-bug injury. Fig. 2.—Portion of full-grown cotton boll, showing lock of cotton ruined by destruction of seed at apex by *Thyanta custator*. Fig. 3.—Lint partly removed from seeds to show discoloration by cotton stainer (*Dysdercus suturellus*); *a*, Seed and attached lint from uninjured boll; *b–c*, same from boll damaged by cotton stainer, showing lint stained deepest close to seed. Fig. 4.—Decay of seeds in immature cotton boll as a result of feeding by plant-bugs; no external evidence of injury. Fig. 5.—Exterior of cotton boll injured by *Calocoris rapidus*. Fig. 6.—Cross section of immature cotton seed damaged by Pentatomid bugs. Fig. 7.—Inside of carpel of cotton boll, showing feeding punctures by plant-bugs. (Arrows point to punctures without proliferation.) Fig. 8.—Cotton boll showing external spots referred to on page 16. (Original.)

relationship in that they occur with greater frequency on bolls injured by plant-bugs than on those entirely free from injury from this source.

Although no external discoloration in the form of spotting of the bolls is known to result directly from the attacks of the representatives of the Heteropterous families thus far studied, and included in this discussion, there is frequently present more or less reliable external evidence of damage. Bolls when severely attacked by plant-bugs may flare, turn yellowish, become flaccid, and finally fall to the ground. This has been observed to take place in bolls as large as $1\frac{1}{8}$ inches in diameter, although it more often occurs in bolls which have attained less than one-half of the normal mature size than in larger bolls. Occasionally a deformity results from the destruction of one lock when the boll is quite small, but this frequently occurs when there is no evidence to connect the deformity with plant-bugs. In addition to these physical changes in the boll, it has been observed with several of the plant-bugs that damaged bolls may be detected in many cases by the yellowish stain produced on the bracts and carpels by the liquid excrement.

INTERNAL APPEARANCE OF BOLLS DAMAGED BY PLANT-BUGS.

Description.—Plant-bug injury to cotton bolls can be positively determined only by means of an internal examination. This subject was treated in the author's report[a] of preliminary investigation of the conchuela in northern Mexico, but additional observations allow of a more complete consideration at this time. While these observations are for the most part based on the conchuela, it has been found that the same effects result from the attacks of the other representatives of the Pentatomidæ, as well as the representatives of Coreidæ and Pyrrhocoridæ upon which studies have been made. The most essential factor in determining injury to cotton bolls by these plant-bugs is the appearance of the inner side of the carpels (Pl. II, fig. 7), where the point of entrance of the insect's setæ is marked by a minute dark spot surrounded by a watery or blisterlike, bright-green area, contrasting distinctly with the light, dull-greenish background. In many cases, particularly in bolls three-quarters grown or more, these blisterlike areas increase to a diameter of 4 or 5 millimeters, but in other cases, more especially in small, rapidly growing bolls, a physiological reaction in the form of a proliferation of plant tissue takes place. This proliferation (Pl. III, figs. 6–8) is of the same nature as that which results from the puncturing of the carpels of the bolls by boll weevils, described by Hunter and Hinds in a previous bulletin of

[a] Bul. 54, Bur. Ent., U. S. Dept. Agr., pp. 29–30, 1905.

this Bureau.[a] That this abnormal growth may be caused by the punctures of Heteropterous insects was first pointed out by the author in his report of preliminary investigations of the conchuela.[b] Since then, in the course of more extended investigations of this and other Heteropterous cotton pests, incidental observations on this point have been made by the writer, a summary of which will be found in a publication by Dr. W. E. Hinds dealing with the relation of the proliferation to the cotton boll weevil.[c] When caused by the boll weevil, this growth can be easily distinguished from that caused by Heteropterous insects by the distinct open puncture which extends through from the outside of the carpel. The entire inner side of the carpels of bolls damaged by plant-bugs is frequently found on examination to present a rough or papulous surface due to the fact that the punctures are so close to one another that the proliferous growths merge together. At Tlahualilo, Durango, Mex., on July 17, 1905, an examination of 100 injured bolls revealing over 4,000 punctures by plant-bugs (practically all by *Pentatoma ligata*) developed the fact that 34 per cent of the punctures had resulted in proliferation. On November 1, 1905, an examination of 25 bolls at Dallas, Tex., from a field where three species of Pentatomidæ (*Nezara hilaris*, *Euschistus servus*, and *Thyanta custator*) occurred in considerable numbers, gave the following results in regard to proliferation, using the lock as the unit:

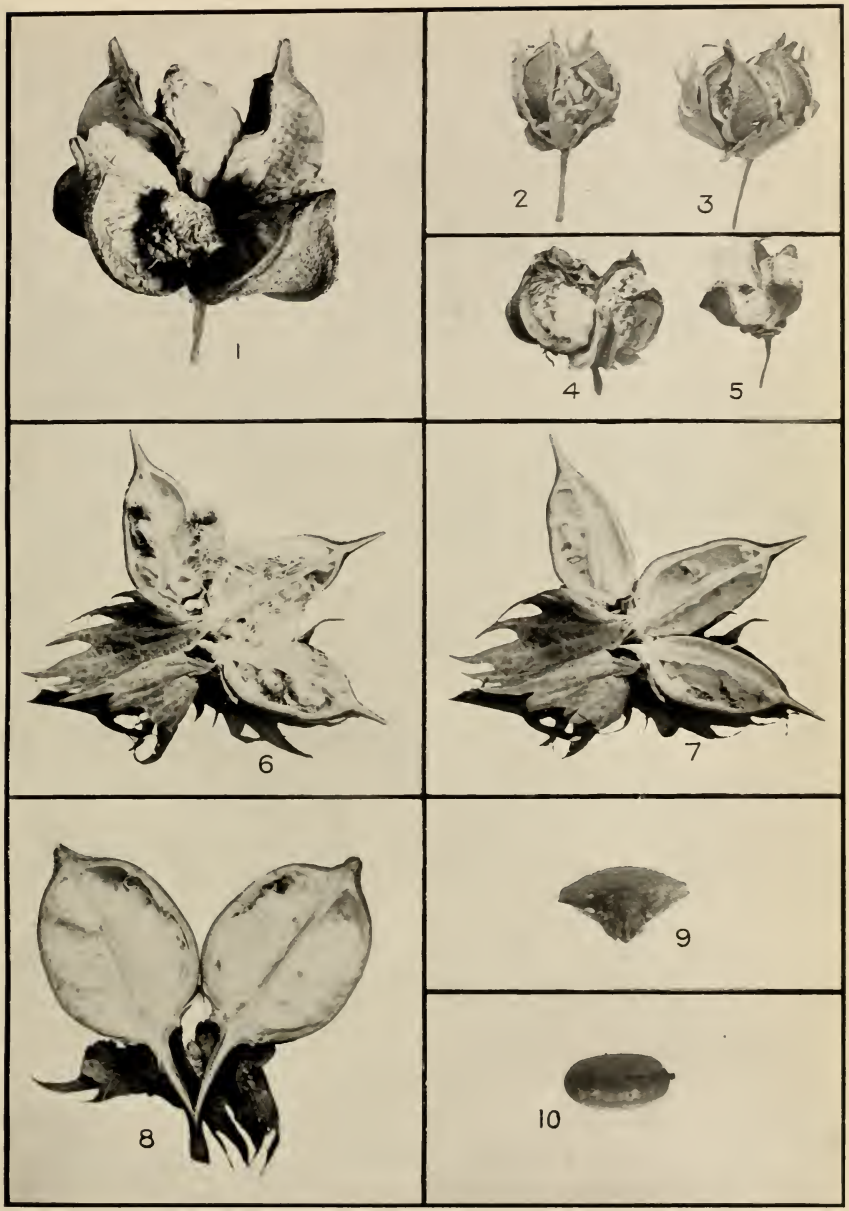
TABLE II.—*Proliferation on inside of carpels of locks fed upon by Pentatomids.*

Size of bolls (diameter).	Locks.					
	Number.	Number showing proliferation.	Per cent showing proliferation.	Destroyed by plant-bugs.	Slightly injured.	Uninjured.
Inches.						
½–⅞	60	42	70	39	3	0
1–1¼	40	11	27	8	3	[a]2
Total.....	100	53	.....	47	6	2

[a] Inside carpels showing three and four punctures, respectively—no apparent injury.

The objective point of the attack by insects investigated is the seed, which they are able to reach with little difficulty by means of the threadlike organs of their mouth-parts, except in large, nearly mature bolls which are protected by the resistance offered by the lint. Except in the larger sized bolls, therefore, a blisterlike spot or prolif-

[a] Bul. 51, Bur. Ent., U. S. Dept. Agr., 1905.
[b] Bul. 54, Bur. Ent., U. S. Dept. Agr., p. 29, 1905.
[c] Bul. 59, Bur. Ent., U. S. Dept. Agr., p. 29, 1906.



EFFECTS OF PLANT-BUG ATTACK ON COTTON BOLLS; EGG AND PUPARIUM OF TACHINID PARASITE.

Fig. 1.—Locks of a cotton boll shriveled by the conchuela. Figs. 2–5.—Small Sea Island cotton bolls destroyed by the cotton stainer. Fig. 6.—Nearly mature Sea Island cotton boll opened to show damage by cotton stainer. Fig. 7.—Same with seeds and lint removed to show feeding punctures and proliferation due to feeding by cotton stainer. Fig. 8.—Cotton boll showing two locks damaged by four and six feeding punctures, respectively, by the green soldier-bug (*Nezara hilaris*). Fig. 9.—Head and thorax of the conchuela, showing egg of Tachinid parasite, *Gymnosoma fuliginosa*, attached to side of prothorax at left. Fig. 10.—Puparium of Tachinid parasite, *Gymnosoma fuliginosa*. (Original.)

A COTTON PLANT SHOWING THE BOLLS INJURED BY THE CONCHUELA.

The cotton plant shown bears 76 bolls, all but 10 of which have been destroyed by this insect. (Original.)

eration on the inner side of the carpel, such as has been described, indicates an injury to the seed or discoloration of the lint directly opposite. When a seed of a rapidly growing boll is fed upon at first the stimulation, probably partly mechanical and partly due to salivary fluids of the bug, causes an increase in the flow of sap to the injured seed, causing a characteristic watery appearance. The seed afterwards gradually becomes discolored (Pl. II, figs. 4, 6) and proliferous tissue is extruded from it in some cases. Punctures near the tip of the lock are most effective in destructiveness; in one case (Pl. III, fig. 8) 4, 6, 16, and 10 punctures per lock, respectively, were found to have produced proliferation from the seed nearest the tip of the boll in each lock and would have prevented the opening out of the cotton if it had been allowed to mature. This is equivalent to complete destruction of the boll. The lint surrounding the point where the insect's mouth-parts enter turns yellowish, and, if the injury is severe, finally becomes a dirty brown and decays (Pl. II, figs. 1, 2; Pl. III, figs. 1–8), which probably is the condition Glover referred to as "the rot."

As the great majority of the punctures are made on the outer half of the bolls, it is there that staining is most frequently found.

In general bolls damaged by plant-bugs when open (Pl. III, figs. 1–5; Pl. IV) are characterized by shriveled locks and only partial spreading of the carpels. The entire lock may become a brownish shriveled mass or the shriveling may be confined to the outer tip. Again, locks may be perfect except for a small stained patch of lint, which, however, might offset the value of the unstained product. Seeds in nearly mature bolls may be destroyed without the surrounding lint becoming badly stained. Consequently where Heteropterous cotton pests are abundant, there is a reduction in the percentage of seed capable of germinating. This phase of the subject of plant-bug damage has received no especial attention.

Proof that described injury is due to plant-bugs.—The evidence that plant-bugs cause injury such as described above amounts to positive proof. Sufficient evidence was given by the author in a previous report and, although much more might be added, it is unnecessary to more than summarize the facts there presented:

1. In a field where the number of conchuelas averaged about 15 per acre and the number of other plant-bugs was a negligible quantity, a specimen of the species named (*Pentatoma ligata* Say) was known to have fed on a single boll for over 36 hours. After several days, during which no bugs were found on this plant, the 15 bolls found on this plant were cut open and examined, with the result that only the one upon which the insect was known to have fed showed the injury described.

2. In the same field two plants upon which 4 and 3 adult conchuelas, respectively, were found, neighboring plants in all directions, being free from the pest at the time, were found to be injured to the extent of 7 bolls out of 15 examined, and 18 bolls out of 20 examined, respectively, while as a check the bolls on the next adjacent plant in the row to each of the foregoing were examined and but 3 injured bolls were found out of a total of over 30.

3. The injury to the bolls which has been described as due to plant-bugs was invariably found in sections of a cotton plantation comprising 27,000 acres, where the conchuela was also found; but in a section where no plant-bugs could be found, although careful search was made for them, no injury of this kind was observed.

4. Cage tests, consisting in the confinement of several adult conchuelas on two plants in a field where no plant-bugs of any kind could be found and where an examination of many bolls indicated entire absence of the supposed plant-bug injury, resulted in 20 bolls of a total of 34 on the caged plants showing the injury a few days later when an examination was made.

AMOUNT OF DAMAGE TO COTTON BY PLANT-BUGS.

It is very probable that each year since cotton has been grown in this country certain localities have suffered from injuries by plant-bugs to the cotton bolls. The cotton stainer (*Dysdercus suturellus*) for many years has been the most serious enemy with which the growers of Sea Island cotton in Florida have had to contend, and the same pest Mr. Schwarz in 1879 (l. c.) declared to be the most formidable enemy of cotton culture in the Bahamas, making questionable the possibility of continued cotton growing on those islands. Professor Sanderson's reference to the damage by the leaf-bug (*Calocoris rapidus*) shows this insect to be capable of considerable destruction to cotton bolls, although no estimate of the amount destroyed has been made.

In the Laguna District of Mexico—the leading cotton-growing section of that Republic—the conchuela accompanied by related pests of less frequent occurrence has been more or less destructive to cotton during the past few years. A specimen of the insect named was sent to this Bureau in August, 1902, from Mexico, by Dr. A. Dugés with the note that it was injurious to cotton at San Pedro de la Colonia, Coahuila, Mexico. In 1903 the same pest attracted considerable attention on account of its unusual abundance in the cotton fields of the Laguna District, particularly those near Tlahualilo, a settlement located in the State of Durango about 50 miles from San Pedro de la Colonia. After investigation by the author it was conservatively

estimated that the damage to the crop for the season 1903–4 was between 10 and 15 per cent. This loss on the one plantation according to this estimate was between 1,200 and 1,500 bales. A study was made of the losses occasioned by these pests in 1905 on the above-mentioned plantation, and the results in detail are considered under the subject of "Destructiveness" of the conchuela. Briefly, this damage on the entire plantation approximated between 5 and 10 per cent, and for one section of 120 acres where the bugs had been most abundant, the destruction as estimated December 4–6, 1905, amounted to 30 per cent of all bolls, including unopened bolls, and 41 per cent of all bolls open at that time.

In this country damage by plant-bugs, with the exception of that by the cotton stainer, has never attracted so much attention as has that by the conchuela in Mexico. Nevertheless, after the characteristics of plant-bug injury have been brought to one's attention, a person is generally impressed with the frequency with which it is met in the cotton fields. The appearance of the conchuela as an enemy of miscellaneous crops in western Texas, near Barstow, in 1905 led to an investigation, in connection with which estimates were made of the damage of the insect to cotton in that locality. As has been stated in a paper dealing with this outbreak, it was estimated that about 10 per cent of the cotton was destroyed near Barstow in 1905. In one field on August 11, 30 per cent of the bolls had been ruined, but the disappearance of the majority of the insects and the continuance of the fruiting of the plants resulted in the percentage of injury being ultimately reduced by one-half.

Plant-bugs occur in cotton fields in the northern half of the State of Texas in much greater abundance than in the southern half, and in 1905, special attention having been given for the first time to the occurrence of plant-bug injuries, it was evident that the aggregate losses from this cause must have been large. It is impossible to approximate the total loss chargeable to the work of plant-bugs in 1905, but it is almost certain that for northern Texas an estimate of 4 or 5 per cent of all bolls is not too high. As a matter of fact the writer's personal examinations in many cotton fields in the section of Texas referred to indicated that this estimate is much too low. Plant-bugs (Pentatomids) were especially abundant near one corner of a 60-acre cotton field at Dallas, Tex., used for experimental purposes by this Bureau. On September 9, 1905, 43 green cotton bolls were picked at random in the section of the field referred to, and of these 29, or 68 per cent, were damaged by the bugs, about 50 per cent being ruined and the others showing badly stained lint. On November 4, 25 bolls were picked at random in a section of the field where these

insects had been abundant, and the results of the examination are summarized in the following table:

TABLE III.—*Injury by plant-bugs to cotton bolls.*

BOLLS.

Diameter.	Number.	Uninjured.	Slightly injured.
Inches.			
½– ⅞	15	[a] 1	0
1–1¼	10	1	[b] 2
Total	25	2	2

LOCKS.

Number.	Destroyed by bugs.	Slightly injured by bugs.	Destroyed by weevils.	Uninjured.
60	45	8	1	6
40	15	11	2	12
100	60	19	3	18

FEEDING PUNCTURES.

Total.	Number in destroyed locks.	Number in slightly injured locks.	Number in uninjured locks.	Average per destroyed lock.	Average per slightly injured lock.	Average per uninjured lock.	Average per destroyed boll.
366	346	20	0	7.7	2.5	0	26
300	186	82	32	12.4	7.0	2.6	30
666	532	102	32	8.9	5.3	1.8	28

Destroyed bolls.		Slightly injured bolls.		Destroyed locks.		Slightly injured locks.		Uninjured locks.
Maximum number of punctures.	Minimum number of punctures.	Maximum number of punctures.	Minimum number of punctures.	Maximum number of punctures.	Minimum number of punctures.	Maximum number of punctures.	Minimum number of punctures.	Maximum number of punctures.
69	7	.....	.....	20	1	5	1	.....
81	15	55	16	22	4	16	1	10

[a] Two locks destroyed by boll weevil larvæ.
[b] Including one boll with 55 feeding punctures by bugs, lint only slightly stained at time of examination.

The data given in Table III will serve as a guide to the relation between plant-bug punctures and the damage which results, as well as an example of a condition which may be occasionally met with in cotton fields of northern Texas where large numbers of plant-bugs are concentrated in small areas. Fortunately such occurrences are not common and are generally restricted to small areas where the surroundings are favorable for the breeding of the bugs in large numbers.

Due credit has not hitherto been given plant-bugs for their part in diminishing the yield of cotton and lowering the quality of the lint. This failure to connect the injury with the cause, as has been pointed out, is largely due to a lack of understanding of the nature of the injury, as well as to the fact that plant-bugs have always been found in cotton fields and except in rare instances no good criterion for judging the amount of loss has been afforded. Field agents of this Bureau, engaged in investigating cotton insects, frequently have met cotton growers in northern Texas who ascribed the shriveled condition of the locks of bolls damaged by these bugs to dry weather. In Florida some cotton growers have explained damage of this same kind as due to the prevalence of wet weather.

Summarily it may be stated that locally plant-bugs frequently cause large losses and throughout large sections of the cotton States cause small but appreciable losses which it is important should be determined in a less cursory manner than heretofore.

PLANT-BUGS AS DISSEMINATORS OF PLANT DISEASES.

Various plant-bugs have been suspected of transmitting fungous and bacterial diseases of plants, but as yet there appears to have been no careful investigation of this matter. That the transmission of the spores of cotton boll anthracnose (*Colletotrichum gossypii* Southworth) by plant-bugs from one boll to another is possible requires no demonstration. An investigator would rather be concerned with the extent to which these cotton-frequenting insects are responsible for the spread of the disease. It is highly probable that the bacillus of the cotton boll "rot" (*Bacillus gossypinus* Stedman) may be disseminated to a greater or less extent by means of plant-bugs whose mouth setæ would furnish a means of direct entrance of the organism to the interior of the boll. The entire subject is one which offers a field for interesting and valuable research, but for the present no estimate can be made of the damage to cotton indirectly caused by plant-bugs through dissemination of pathogenic fungi and bacteria.

THE CONCHUELA.

(*Pentatoma ligata* Say.)

(Pl. I, fig. 1.)

HISTORY.

The conchuela [a] was described in 1831, but first became known as an insect of economic importance when, in August, 1902, specimens were received from a correspondent of the Bureau of Entomology,

[a] This is the common name used for this insect by the natives of the Laguna District of Mexico. It is a Spanish word meaning "little shell" and is based on a fancied resemblance to a shell.

with the note that the species was injuring cotton in the Laguna District of Mexico at San Pedro de la Colonia, State of Coahuila. In March, 1904, the author was directed by the Entomologist to investigate a reported partial destruction of the cotton crop by an unknown pest in the Laguna District of Mexico. The specific report emanated from a large plantation of between 25,000 and 30,000 acres of cultivated land located in the northern portion of the Laguna District, the headquarters being at Tlahualilo, State of Durango. At the season of the year when the first visit was made, although the cotton stalks were still standing in the fields, it was impossible to establish positively the relationship between the conchuela and the large number of ruined bolls present everywhere on the plantation. The second visit to Tlahualilo from August 30 to September 8, 1904, resulted in this point being definitely determined as well as in the procuring of considerable information concerning the insect and its work. The details of these preliminary investigations were reported on in a previous bulletin of this Bureau.[a]

The investigations were continued in 1905 at Tlahualilo, where the author of this report spent the month of July and a week in the early part of December.

The conchuela has recently become known as a pest in western Texas, where, in 1904 and 1905, near Barstow, it occasioned considerable loss to seed crops of alfalfa, and in the latter season proved, in addition, its destructiveness to miscellaneous crops, including peaches, grapes, peas, and other garden products. The report of the investigation of this unexpected outbreak has been published under a separate title.[b]

DISTRIBUTION.

The distribution of *Pentatoma ligata* is a wide one, the species occurring rarely in the eastern half of the United States, and with much more frequency in the arid and semiarid regions of the Western States and Mexico. It is probably of considerable significance that hitherto localities where this species has been found to occur in large numbers have been situated in the Lower Sonoran faunal region of the Lower Austral zone. In Texas miscellaneous collections for three years by members of the Bureau of Entomology engaged in cotton boll weevil investigations have not included a single specimen of *Pentatoma ligata* taken east of the semiarid region or approximately the ninety-eighth degree of longitude. A single specimen in the collection at the office of the Texas state entomologist bears the label Beeville, Tex., which is situated between the ninety-seventh and the ninety-eighth degrees of longitude and is the easternmost

[a] Bul. 54, Bur. Ent., U. S. Dept. Agr., pp. 18–34, 1905.
[b] Bul. 64, Pt. I, Bur. Ent., U. S. Dept. Agr., 1907.

locality in Texas from which the writer has seen a specimen of the species. West of the ninety-eighth degree of longitude specimens have been collected at the following points and elevations in the State of Texas: San Diego, 300 feet; Abilene, 1,700 feet; Barstow, 2,500 feet; Llano, 1,000 feet; San Angelo, 1,800 feet; San Antonio, 675 feet; Clarendon, 2,700 feet. The known Mexican localities where the species has been collected, with their elevations, are: San Pedro de la Colonia, Coahuila, 3,600 feet; Tlahualilo, Durango, 3,700 feet.

FOOD PLANTS.

Like most other plant-feeding Pentatomids whose habits are known, the conchuela has a wide range of food plants and shows a decided preference for fruits and seeds. In Texas and Mexico its principal food in uncultivated regions is the bean of the mesquite (*Prosopis* sp.) and the berry of a common wild solanum (*Solanum elæagnifolium*), known among the natives of Mexico as "trompillo." Of these two the former seems to be preferred according to observations in northern Mexico where the two food plants grow together on the arid plateaus. Records of other wild food plants of the species, with the observer and locality, are as follows: Spanish bayonet or bear grass (*Yucca* sp.), Barstow, Tex., J. C. Crawford; wild currant (*Ribes* sp.), San Antonio, Tex., W. E. Hinds and J. C. Crawford; sage, Clarendon, Tex., W. D. Pierce. Records of cultivated food plants, with the observer and locality, are as follows: Cotton, alfalfa, grapes, corn, chilli pepper, and tomato, Tlahualilo, Durango, Mexico, A. W. Morrill; peaches, Barstow, Tex., J. C. Crawford; cotton, grapes, Milo maize, sorghum, alfalfa, peas, tomato, Barstow, Tex., Crawford and Morrill. The fact that in 1905, at Barstow, Tex., the conchuela attacked several of these crops in sufficient numbers to cause considerable damage has been referred to under the subject of the history of the species. The range of food plants which has been recorded points to the likelihood that this insect may use as a food plant almost any of our cultivated grains, fruits, and vegetables which circumstances may place in the way.

DESCRIPTION.

ADULTS.

(Pl. I, fig. 1; text fig. 1.)

This species belongs to the subgenus Chlorochra Stål, and in common with certain other members of this group exhibits a wide variation in color. The general color is usually dull olivaceous, frequently either grayish, pinkish, purplish, or greenish, and occasionally black or brown. The punctures are black or dark gray. The species is most strikingly characterized by its general dark color, with the

lateral margins of the thorax above and below, the basal third to two-thirds of the costal margins of the wing corium, and the tip of the scutellum varying in color in different specimens from pale yellow to bright crimson. In a series of 63 specimens collected at random the range in length was found to be from 12 to 16.5 mm. While in this species there was one of either sex measuring 16.5 mm., the females in general are slightly larger than the males. Among 10 specimens of each sex collected at random in a cotton field, the average length was 15.1 mm. in the case of the females and 14.1 mm. in the case of the males, the former ranging from 14 to 16.5 mm., the latter from 13 to 14.5 mm.

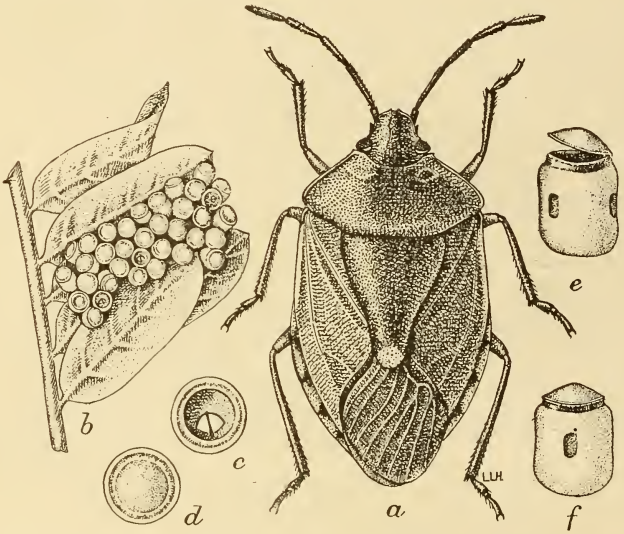


FIG. 1.—The conchuela (*Pentatoma ligata*): *a*, Adult bug; *b*, egg-mass on leaves; *c*, egg just before emergence of nymph; *d*, egg at an earlier stage of development; *e*, egg from side showing exit hole at the top; *f*, egg closed. *a*, *b*, enlarged; *c-f*, greatly enlarged. (Author's illustration.)

EGGS.

(Text fig. 1; Pl. V, fig. 1.)

The writer has described the egg of this species in a previous report. From the examination of 25 eggs deposited by various females the dimensions may be stated as follows: The greatest diameter of individual eggs varies from 0.95 to 1.22 mm., rarely exceeds 1.1 mm., and averages about 0.98 mm.; the height varies from 1.2 to 1.45 mm. and averages about 1.28 mm. The egg is irregularly ovoid in form. When first deposited it is pale green but the chorion soon turns white except for certain areas which are translucent and grayish in color, turning to dark gray or brown as the embryo develops.

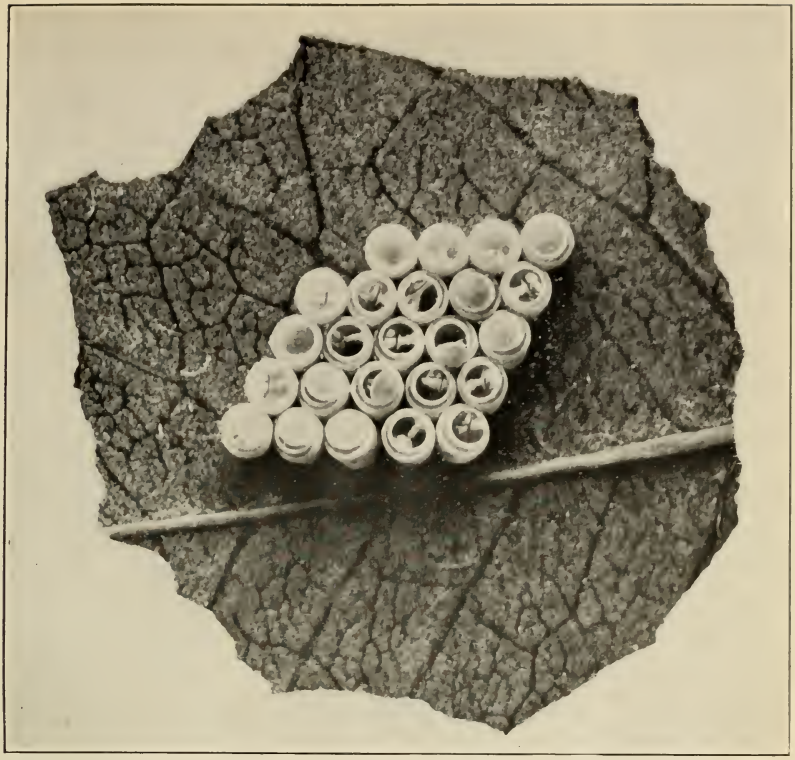


FIG. 1.—EGG BATCH OF CONCHUELA (PENTATOMA LIGATA), SHOWING HATCHED AND UNHATCHED EGGS. ENLARGED 6⅔ DIAMETERS. (AUTHOR'S ILLUSTRATION.)

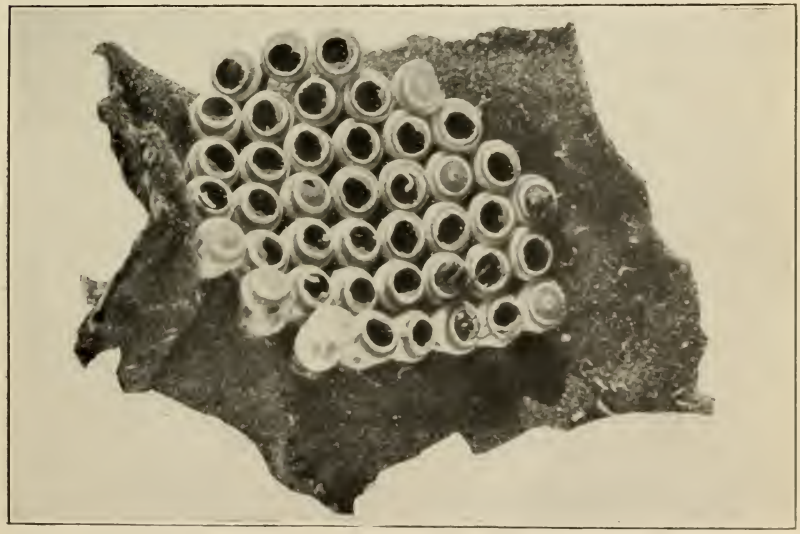


FIG. 2.—EGG BATCH OF CONCHUELA FROM WHICH 32 PROCTOTRYPID PARASITES (TELENOMUS ASHMEADI) HAVE EMERGED ENLARGED 6⅔ DIAMETERS. (AUTHOR'S ILLUSTRATION.)

This illustration shows three parasites, including male and female, ready to emerge; also an egg destroyed, probably by an ant.

NYMPHS.

(Figs. 2–6.)

First instar.—In the first instar the head and thorax are deep brown. The abdomen is deep slate-gray with a middorsal series of shiny black spots, whitish at the marginal incisures between which just inside the margin of each segment is a spot of deep brown. Specimens in this stage vary in length from 1 to 1.75 mm. and in width from 1 to 1.5 mm. according to individual variation and age.

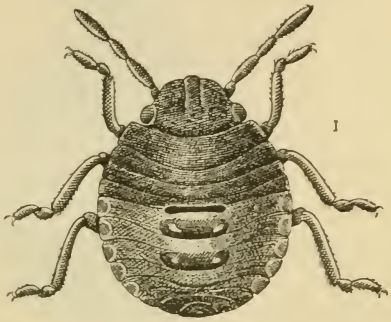


FIG. 2.—The conchuela: Nymph, first instar. Enlarged 21 diameters. (Original.)

Second instar.—The head and thorax of the nymphs in the second instar are shiny black, the thorax being margined with yellowish or orange-red. The abdomen above is dark violaceous, the venter paler. There is a series of black spots on the dorsum of the abdomen as in the first instar and a ventral series of black spots is sometimes present along middle one to each of the last four segments. The abdominal segments above and below have a yellowish or orange-red border, which narrows posteriorly. The length of second-instar nymphs varies from 1.6 to 2.5 mm., and the width from 1.3 to 2 mm.

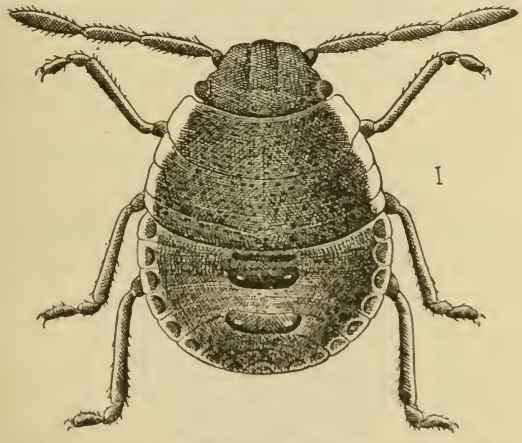


FIG. 3.—The conchuela: Nymph, second instar. Enlarged 21 diameters. (Original.)

Third instar.—The nymphs in the third instar are much like those of the second but are subject to greater variation in color. There is more or less olivaceous along the middle of the venter of the thorax. The abdomen usually has a pale violaceous ground color and dark violaceous spotting. The ventral series of spots is usually distinct, consisting of one spot on each of the segments from the fourth to the eighth, the anterior spot being the smallest. Frequently inside the reddish border on each segment from the second to the ninth is a more or less thickened crescentic black mark. Corresponding

markings are sometimes present on the venter. The lines of the segments are usually dark in color. The length in this instar varies from 3.5 to 4 mm., and the width from 3 to 3.5 mm.

Fourth instar.—The fourth instar is characterized by the first external evidence of the developing wing-pads. The ventral side of the head, and sometimes the two basal segments of the beak, are more or less olivaceous. The black crescentic markings inside the margin of the abdominal segments are more distinct than before. Otherwise the color corresponds very nearly with that of the third instar. The length of the fourth-instar nymph varies from 4.8 to 6.5 mm., and the width from 3.7 to 5 mm.

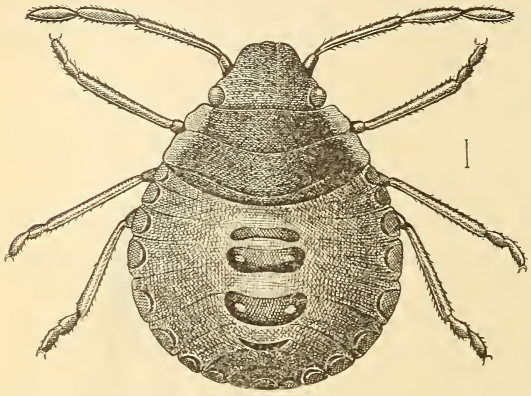


FIG. 4.—The conchuela: Nymph, third instar. Enlarged 13 diameters. (Original.)

Fifth instar.—In the last or fifth nymphal instar the head and thorax are rarely uniformly black as in the two preceding instars but are more or less olivaceous, with black punctures. The venter of the thorax has usually an olivaceous but sometimes a pale purplish or rosaceous ground color, with black punctures and markings. The basal segments of the legs are more or less olivaceous. The abdomen is colored as in the previous instars except that the ventral series of spots along the mesal line is either absent or only faintly indicated. The length of the nymphs in the fifth stage varies from 9 to 11 mm., and the width from 6 to 8 mm.

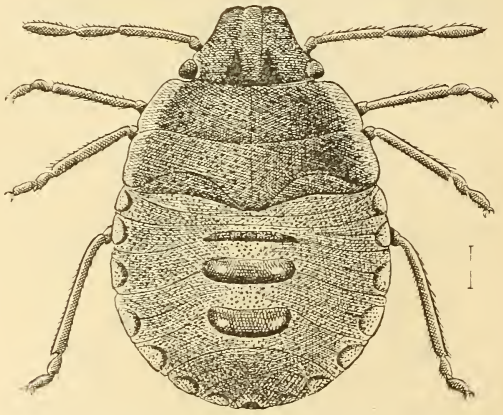


FIG. 5.—The conchuela: Nymph, fourth instar. Enlarged 10 diameters. (Original.)

LIFE HISTORY.

Methods of Study.

Studies in the life history of this and other species of plant-bugs were conducted in an improvised laboratory at Tlahualilo, Durango, Mexico, during July, 1905, and at the boll weevil laboratory at Dallas, Tex., after August 5, 1905. The insects were confined in lantern chimneys covered at the top with cheese cloth held in place by rubber bands, the number of adults to a cage ranging from one to five. The adults were provided daily with freshly picked green cotton bolls until about October 1, after which fresh bolls were supplied every two days as long as any were available. Nymphs were fed upon fresh green cotton leaves or twigs, cotton bolls cut or broken in two, and immature cotton seed from which the lint was first removed. Records were made at least once each day, noting deaths, eggs deposited, time of examination, etc. During the writer's occasional absences from the laboratory on field work these records were made by Mr. W. W. Yothers and Mr. A. C. Morgan.

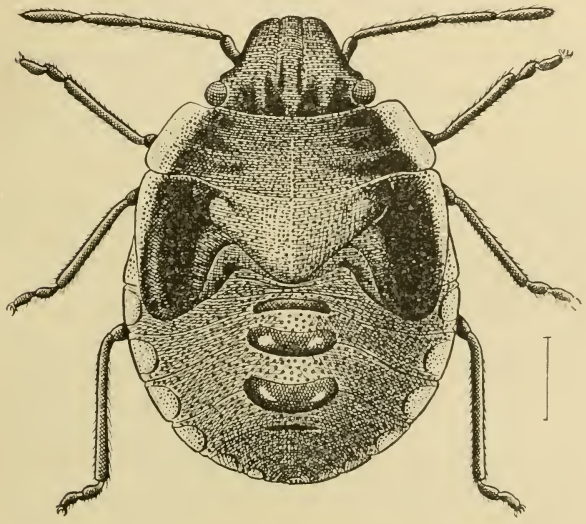


Fig. 6.—The conchuela: Nymph, fifth instar. Enlarged 6 diameters. (Original.)

Adults.

Period between maturity of adults and beginning of egg-laying.

The data at hand on the length of time elapsing from the maturity of the adults to the beginning of oviposition are not sufficiently extensive to permit the drawing of conclusions. Apparently the specimens upon which the data are based were influenced by the laboratory conditions, for the period varied in length from 23 to 95 days and averaged 45 days in the case of the five specimens which were reared to maturity in the laboratory during July and August and which deposited one or more batches of eggs. Three females in addi-

tion to the foregoing lived 6, 34, and 125 days, respectively, but deposited no eggs.

REPRODUCTION.

Monthly and daily rate of oviposition and relation to temperature.—Including all the female specimens of *Pentatoma ligata* upon which observations were made, the average daily rate of egg production was 1.45. Omitting the month of November, during which no eggs were deposited, the rate was 1.8 per day, while up to October 1 the rate was 2.4 per day. The more important data on egg deposition are summarized in the following table:

TABLE IV.—*Rate of egg deposition of the conchuela.*

Lot.	When collected.	Where collected.	Number of females.	Total number of eggs deposited.	Average number of eggs deposited per insect per day.					
					July.	Aug.	Sept.	Oct.	Nov.	Total.
	1905.									
A	July 6–10	Tlahualilo, Mexico.	21	2,755	2.74	3.05	0.51	0	0	1.92
B	Aug. 11–12	Barstow, Tex	8	592	.....	4.6	.57	0	0	2.5
C	Sept. 12	do	14	1,271	.....	.....	6.27	1.56	0	5.4
D	Oct. 13	do	[a] 10	0	.....	.....	.....	0	0	0

[a] These insects were soft, indicating that they were newly matured.

A study of the effect of temperature on egg production in the species here considered leads to the conclusion that the effective temperature as concerns egg-laying in the faunal region where these records were made, i. e., Lower Austral, is a little less than 75° F. The effect of temperature changes upon egg production is well illustrated by the data given in the following table relating to insects of lot A referred to in Table IV:

TABLE V.—*Relation of temperature to egg-laying in the conchuela.*

Period.	Average daily mean temperature.	Number of eggs per day deposited by 20 females.
1905.	°F.	
July 11–15	82.6	67
July 16–20	75.3	11
July 21–25	78.1	61
July 26–30	80.8	66

Egg-laying capacity.—A summary of the laboratory records regarding egg-laying capacity is presented in the following table:

TABLE VI.—*Egg-laying capacity of specimens of the conchuela collected in cotton fields.*

Lot.	When collected.	Number of females.	Average number of eggs deposited per female.	Maximum number of eggs deposited per female.
	1905.			
A	July 6	21	131	321
B	Aug. 12	8	74	(a)
C	Sept. 12	14	91	b 122
D	Oct. 13	10	0	0

a No individual records kept for this lot.
b This record is for the only female specimen isolated from others of same sex.

The above records are based on females collected in the field, lot A at Tlahualilo, Mexico, and the remaining lots from Barstow, Tex. In all cases it may be presumed that the specimens had deposited eggs before the records began. From the fact that few nymphs were present, while the number of adults was rapidly increasing in the field where lot A was collected, it is probable that the migrating insects consisted of males and females which had recently reached maturity in the surrounding mesquite and arrived at the cotton field as a consequence of their search for a better food supply. The status of these insects in the mesquite as hereafter described adds further evidence to the support of this supposition. If we consider, accordingly, that the individuals of lot A had averaged to begin egg-laying one week before the above records begin, the daily rate being the same as for the remainder of the month, the average number of eggs deposited by each female of the lot would be 150 and the maximum number 340.

Duration of fertility.—Four lots of insects were used in testing the duration of fertility in isolated females. The results are summarized as follows:

TABLE VII.—*Duration of fertility in females of the conchuela isolated from males.*

Lot number.	Number of females.	When isolated.	Deposition of first infertile egg.		Deposition of last fertile egg.	
			Date.	Number of days after isotion.	Date.	Number of days after isotion.
		1905.	1905.		1905.	
1	5	July 10	Aug. 11	32	Aug. 26	47
2	1	July 10	Aug. 7	28	Sept. 14	66
3	5	July 10	Sept. 10	60	Sept. 10	60
4	2	July 11	Aug. 16	36	Aug. 23	44
Average				39		54

Two points of importance are brought out by the data given in Table VII. First, it is evident that the duration of fertility after isolation does not cover the normal egg-laying period of the female. Second, the end of the period of fertility in the female is not well marked and a considerable period may elapse between the deposition of the first infertile egg and of the last fertile egg.

PROPORTION OF SEXES.

While observations on a small scale indicated a preponderance of the number of females over the number of males, the final and most conclusive observation as well as the totals show that the two sexes occur in about equal abundance. The difference in favor of the female sex shown in the totals is less than 2 per cent over an equal division, a difference which might occur in any arbitrarily chosen series from a large number of specimens including exactly one-half of each sex.

TABLE VIII.—*Proportion of sexes of the conchuela.*

When collected.	Where collected.	Number of males.	Number of females.	Total.
September, 1904	Tlahualilo, Durango, Mexico.	7	12	19
July 11, 1905	do	17	25	42
July 12, 1905	do	247	253	500
Total		271	290	561

LONGEVITY.

Adults collected in the field.—Provided that an abundance of food is available, the length of life of the adults when protected from their natural enemies is dependent upon the season of the year in which the insects reach maturity. The following tabulations summarize the data concerning this point in the life history of the conchuela derived from the laboratory records.

TABLE IX.—*Summary of records of longevity of adults of the conchuela collected in cotton fields.*

Number of specimens.		Where collected.	When collected.	Maximum longevity. (Days.)		Average longevity. (Days.)	
♀	♂		1905.	♀	♂	♀	♂
21	6	Tlahualilo, Durango, Mexico	July 6–10	142	79	71	37
8	.....	Barstow, Tex	Aug. 12	83	.....	29	.....
14	2	do	Sept. 12	29	[a]9	17	9
5	0	Clarendon, Tex	Sept. 19	[b]91+	.....	53	.....
9	11	Barstow, Tex	Oct. 13	[b]67+	[c]67+	[b]67+	53+

[a] Apparently parasitized by Tachinid fly but no parasite emerged from body of supposed host.
[b] In hibernation test December 1; all alive December 19; all dead March 8, 1906.
[c] Alive January 17, 1906, in hibernation cage; dead March 8, making 98+, but to keep on same basis as other specimens the record was included only up to December 19, 1905.

In order to show in a more graphic manner the vitality of the females collected at various times during the year, the data concerning that sex are arranged in the form presented below:

TABLE X.—*Longevity of adult females of the conchuela collected in field.*

When collected.	Where collected.	Number of specimens.	Number alive in sucessive months.[a]					
			July.	Aug.	Sept.	Oct.	Nov.	Dec.
1905.								
July 6–10	Tlahualilo, Durango, Mexico	21	21	20	13	7	4	0
August 11–12	Barstow, Tex	[b] 8	.....	8	4	1	1	0
September 12	....do	[c] 14	.....	.....	14	6	0	0
September 19	Clarendon, Tex	5	.....	.....	5	5	2	0
October 13	Barstow, Tex	10	.....	.....	.....	10	10	[d] 10

[a] Record on the first day of each month following that during which collection was made.
[b] Not including 6 which died in less than five days after trip from Barstow to Dallas, Tex.
[c] Not including 2 which died in less than five days after trip from Barstow to Dallas, Tex.
[d] Hibernating alive December 19.

All of the above records on the duration of adult life are incomplete, as it was not definitely known in any case how long the insect had been in the adult stage when collected. Conditions at Tlahualilo indicate that the specimens collected at that point had been in the adult stage, on the average, about ten or twelve days. There were no means of judging on this point in the case of the specimens collected during August and September, but those collected on October 13 were still soft and specimens which died in transit contained no recognizable eggs; hence with little doubt this lot of specimens had matured within the week preceding their collection.

Adults reared to maturity in the laboratory.—As will be explained under the subject of the molting of nymphs, imperfect or crippled adults are frequently produced in the laboratory. From the ten apparently normal adults which reached maturity in confinement the most complete records on longevity were obtained.

TABLE XI.—*Summary of records of longevity of adults of the conchuela which reached maturity in laboratory.*

Number of specimens.		Where collected.	When mature.	Maximum longevity. (Days.)		Average longevity. (Days.)	
♀	♂			♀	♂	♀	♂
			1905.				
1	1	Tlahualilo, Durango, Mexico.	July 21	[a] 49+	[a] 49+	.....	.....
2	.....	.....do.....	July 29 and August 4	[b] 143+	.....	86+	.....
2	.....	Barstow, Tex	August 7 and 14	[b] 127+	.....	76+	.....
2	2	.....do.....	August 15 and 16	[b] 126+	69	71+	53

[a] Specimens lost. [b] Used in hibernation test December 1, 1905; alive December 19, 1905.

From the data given in the foregoing tables we are able to estimate approximately the length of adult life of the conchuela under

laboratory conditions. Fortunately the natural enemies of the insect and probably also its greater activity in the field materially lessen the average duration of adult life below that which was found to obtain in the laboratory. A cage test in a cotton field failed to give positive evidence regarding normal longevity of the adults on account of the fact that the amount by which the insects' lives were shortened through their attempt to escape can not be estimated. Seventeen specimens which became adult between July 25 and July 31 were confined in a wire cage placed over a cotton plant bearing a dozen bolls and many blooms and squares. The cage rested on cheese cloth in order to facilitate the finding of dead bugs. On August 27 Mr. John Conduit, of Tlahualilo, noted that 10 live adults could be seen and no dead ones. On September 2 Mr. Robert Vaughan, of Tlahualilo, noted that there were 5 dead specimens, and on October 15 another dead specimen was observed. Live adults were noted as follows: September 10, 2; September 20, 1; October 9, 1; October 12, 2; October 15, 1; October 18, 1; October 20, 0; October 24, 0; October 31, 0. The number of adults noted on each date simply includes those which could be seen from outside the cage. It is not impossible that some of the insects found an opportunity to escape, as of the 17 insects only 7 can be definitely accounted for. The results show that 5 died in from 32 to 37 days, 1 in between 45 and 50 days, and 1 in between 78 and 83 days after reaching the adult stage. The sex of the specimens used in this cage test was not recorded.

Length of life when deprived of food.—Without food the life of adult conchuelas is very short in summer temperatures. On July 21, 28 adults—12 females and 16 males—taken on cotton plants at 11.30 a. m. were placed, at 12.30 p. m., without food, in a wire cage whose dimensions were 2 by 1 by 1 foot. The insects were very restless and flew almost continuously during daylight from one side to the other in the cage. In 33 hours from the time they were last fed only 7 of the 28 were alive and in 48 hours all were dead. In a second experiment 17 adults—8 females and 9 males—taken on cotton plants July 22 at 5 p. m. were placed, at 6 p. m., in a lantern globe loosely filled with soft, crumpled paper to prevent the insects from exhausting themselves by attempting to fly. Twenty-six hours after being deprived of food 9 of the 17 were dead and 41 hours after being deprived of food the last surviving specimen was noted as dying. The daily mean temperature at Tlahualilo at the time of the foregoing tests in the starvation of the conchuelas was between 75° and 80° F. On September 20, two specimens of this species were collected in western Texas and confined in separate pill boxes without food. These two specimens lived 5 and 6 days, respectively. The length of life without food is clearly dependent upon

temperature conditions, as will be further discussed under the subject of hibernation.

RELATION OF TEMPERATURE TO ACTIVITY OF ADULTS.

Observations were made in October on some surviving specimens of the lots included in Table IX for the purpose of obtaining information on the effect of temperature on the feeding of these insects. The number of observations is too small to determine this point in more than a general way, and we are justified only in concluding that the degree of temperature at which feeding ceases is between 52° and 60° F.

TABLE XII.—*Observations on relation of temperature to feeding of the conchuela.*

Date of observation.	Hour.	Temperature.	Number of adults feeding.	Number of adults not feeding.	Remarks.
1905.		° F.			
October 11	8 p. m.	55–60	8	8	Specimens in laboratory.
October 19	7.15 p. m.	66	7	12	Do.
October 20	8.30 a. m.	49	0	14	Specimens out of doors.
Do	8.15 p. m.	52	0	19	Specimens in laboratory.
October 21	8.30 a. m.	51	0	[a] 19	Do.

[a] Including one with setæ inserted in boll, but motionless and evidently not feeding. Plant-bugs in the laboratory have even been observed to die in this position.

For comparison, observations were also made with a miscellaneous lot of Pentatomids, including specimens of *Pentatoma sayi, Euschistus servus, Nezara hilaris,* and *Thyanta custator.* These are summarized as follows:

TABLE XIII.—*Observations on relation of temperature to feeding of miscellaneous Pentatomids.*

Date of observation.	Hour.	Temperature.	Number of adults feeding.	Number of adults not feeding.
1905.		° F.		
October 11	8 p. m.	55–60	5	5
October 19	7.15 p. m.	66	4	3
October 20	8.15 p. m.	52	0	7

EGGS.

PERIOD OF INCUBATION.

As is the case with all insect eggs, the developmental or incubation period of the eggs of the conchuela is influenced to a marked degree by slight variations in temperature. From the entire lot of egg-batches deposited in the laboratory, numbering over 160, 26 have been selected for a study of the relation of temperature to incubation period, owing to the comparative completeness of the records. The

number of intervening calendar days has been taken as the basis and the additional periods approximated by a plan which has been followed throughout and which is believed to have produced very nearly correct averages. To the number of intervening calendar days has been added the known additional hours and one-half the hours between observations during which egg-laying or hatching might have occurred. In many cases the exact time of the egg-deposition or of hatching was noted, consequently lessening the chances for error. For example, a female was observed in the act of depositing an egg-batch at 4 p. m., July 16. This batch had hatched when the record was taken at 3 p. m. on July 23. The number of intervening calendar days in this case was six. The known additional period is 8 hours, 4 p. m., July 16, to 12 midnight. The period preceding the time the eggs were first noted as having hatched, during which no observations were made, was 23 hours, one-half of which is added to the known period of 8 hours, making practically five-sixths of a day. This added to the intervening calendar days gives $6\frac{5}{6}$ days as the approximate incubation period.

TABLE XIV.—*Relation of temperature to period of incubation of eggs of the conchuela.*

Place.	Period.	Number of egg batches.	Number of eggs.	Range.			Average.		
				Intervening calendar days.	Approximate incubation period.	Average daily mean temperature for intervening days.	Daily mean temperature.	Approximate incubation period.	
	1905.								
Tlahualilo, Durango, Mexico.	July 14–23	3	99	6 to 6	$7\frac{1}{6}$ to $6\frac{2}{3}$	75.4 to 76.1	75.8	6	19
Do	July 22–30	5	234	5 to 4	$6\frac{1}{12}$ to $5\frac{1}{6}$	79.1 to 79.5	79.4	5	9
Dallas, Tex	Aug. 6–Sept. 15	11	350	3 to 2	$4\frac{1}{6}$ to $3\frac{1}{6}$	80.1 to 86	82.8	3	15
Do	Sept. 16–Oct. 5	7	313	6 to 4	7 to 5	73.7 to 75	74.3	5	23
Summary with averages	July 14–Oct. 5	26	996	2 to 6	$3\frac{1}{6}$ to $7\frac{1}{6}$	73.7 to 86	78	5	8
					Days.	°*F.*	°*F.*	*Days.*	*Hours.*

From the last three columns of the above table can be computed the average effect of 1° of temperature on the duration of the incubation period within the limits noted.

TABLE XV.—*Effect of 1° of temperature on incubation period of eggs of the conchuela.*

Place.	Range, average daily mean temperature.	Number of degrees represented by range.	Increase or decrease in incubation period corresponding to 1° of temperature.
Tlahualilo, Durango, Mexico	75.8 to 79.4	3.6	0.39 days or 9 hrs. 30 min.
Dallas, Tex	74.3 to 82.8	8.3	.27 days or 6 hrs. 30 min.

The average of the Tlahualilo and Dallas records shows that between the limits of 74.3° and 82.8° the average increase or decrease in the incubation period corresponding to a single degree of temperature is

estimated at 7 hours and 55 minutes. It is a notable coincidence that in the case of the eggs of the spined soldier-bug (*Podisus maculiventris* Say) the author found in Massachusetts that with an average daily mean temperature ranging between 62° and 72°, 1° of temperature corresponded with approximately 7 hours and 40 minutes.[a]

An instance of a much more prolonged incubation period was not included in the foregoing table but was reserved for separate discussion, as it is evidently a case of intermittently arrested development, due to low temperatures. The egg batch in question numbered 28 eggs and was deposited on October 17; 13 hatched on November 3. The average daily mean temperature[b] during the 16 days of incubation was 65.7° F. The average daily maximum for this period was 72.3° F. and the average daily minimum was 59° F. To the author it seems plain that the 16-day period can only be explained by the supposition that development of the eggs was arrested from time to time by the low temperatures. Here again a comparison with the records obtained from the eggs of the other species of the Pentatomid mentioned in the preceding paragraph is instructive as showing the adaptation of the physiological processes of the two species to climatic conditions. The eggs of the spined soldier-bug at Amherst, Mass., with practically the same average daily mean temperature (65.5° F.) hatched in 8½ days, or after a period one-half as long as in the case of the eggs of the conchuela.

PROPORTION HATCHING IN THE LABORATORY.

In many cases no note was made as to whether or not eggs hatched, but the records of nearly a thousand eggs will suffice to give fairly accurate knowledge on the subject. The eggs selected were deposited during July and August by conchuelas collected in the cotton fields at Tlahualilo and abnormal conditions were eliminated, as will be explained. The total number of eggs was 942, and of these 68, or 7.2 per cent, failed to hatch. Eggs of the conchuela deposited in the field seldom fail to hatch if not destroyed by parasites or predaceous enemies. The number of unparasitized egg-batches collected in the field is too small to permit the drawing of conclusions concerning the proportion that hatch, and for information on this point laboratory data must be used. If, however, we omit records of eggs from infertile females and of certain abnormal eggs, mechanically prevented from hatching, there is no reason to expect any appreciable difference in the proportion of eggs hatching under laboratory conditions and those hatching under normal field conditions. Infertile eggs have never been collected in the field nor has any egg-laying

[a] Bul. 60, Bur. Ent., U. S. Dept. Agr., p. 158, 1906.

[b] Records based on a recording thermometer in the room with the eggs.

female brought from the field into the laboratory proved unfertilized; hence this factor should be eliminated from the laboratory records in order to make them comparable with actual field conditions.

As an illustration of the mechanical prevention of hatching referred to, a conchuela in one instance deposited eggs in two layers, the nymphs in the lower layer of eggs, numbering 20, being of course unable to escape from the shells. This manner of depositing the eggs was evidently due either to interference by other specimens in the cage or to a lack of sufficient leaf-area, both of which conditions are abnormal. Occasionally eggs are deposited, both in the laboratory and in the field, wrong side up with relation to other eggs of the batch. This also usually results in mechanical prevention of hatching and accounts for the failure to hatch of somewhat less than 1 per cent of the 942 eggs referred to above. Other eggs may fail to hatch owing to the exit hole at the top being abnormally small, as the author has observed to occur in two instances with eggs of the harlequin cabbage bug (*Murgantia histrionica* Hahn). The extent of this abnormal condition may not be noticeable, yet sufficient to prevent emergence of the nymph. Still other eggs may be abnormal in the respect that the lid which must be raised to permit the escape of the nymph is too solidly attached to the neck of the egg in proportion to the strength of the insect.

EFFECT OF LOW TEMPERATURE ON VITALITY.

An experiment was made to determine the extent to which development of eggs might be retarded or otherwise affected by low temperature. In this experiment 12 egg-batches comprising 288 eggs were used, all of which were deposited between August 27 and September 16 by 8 different females. Each batch of eggs was placed in an ice box within 24 hours after being deposited and kept there until November 2, with the temperature almost invariable and averaging 49° F. Upon examination it was found that the eggs had been entirely destroyed, being shriveled so that there could be no doubt of their condition. It would seem, therefore, that such long-continued low temperatures are fatal to the conchuela in the egg-stage.

HATCHING.

As the eggshell is nontransparent, the developing nymph is invisible up to the time of hatching. The stout spine on the egg-burster is directed at the suture between the lid and the neck of the egg at a point opposite the hinge. By pressure from below a split is made along the suture and the pale pinkish head of the nymph surmounted by the egg-burster appears beneath the partially opened lid. The integument of the insect being soft, the emergence is by slow, scarcely perceptible peristaltic movements, the egg-burster slipping over the

head and along the venter as the emergence progresses. The position of the nymph in the egg is with the dorsum toward the hinge of the lid. The antennæ and legs are closely appressed to the body and extended directly backward. Movement of the antennæ and legs begins as soon as they are free from the egg and emergence is not completed until the legs are sufficiently strong to enable the insect to cling to the egg-batch. Individual nymphs have been observed to emerge in from 12 to 15 minutes after the lid is first raised. Emergence of nymphs from a batch of eggs usually extends over a period of less than 1½ hours, but activities in this line as in others are largely under the influence of temperature. A record on October 10 shows a difference of 2 hours and 15 minutes between the appearance of the first nymphs and last nymphs to emerge from a batch of 13 eggs.

Nymphs.

Duration of nymphal stages.

Under normal summer temperatures.—In spite of the most careful attention one can reasonably give, the death rate of Pentatomid nymphs under observation in the laboratory is very high. In no case were nymphs of the conchuela reared to maturity in the laboratory, but the duration of the various stages was determined by more than 35 individual records. The prevailing temperature conditions seem to control the duration of the nymphal stages of these and other Pentatomids, while a lack of food supply seems to result only in either a stunted growth or death from starvation. During the months of July and August, 1905, at Tlahualilo, Durango, Mexico, and Dallas, Tex., respectively, the data summarized in the following table were obtained, being based on from 5 to 35 specimens in each instar.

Table XVI.—*Observations on duration of nymphal stages of the conchuela.*

Stage.	Average duration.	Minimum duration.	Maximum duration.
	Days.	*Days.*	*Days.*
First instar	4.5	4	5
Second instar	6	5	7
Third instar	8	6	10
Fourth instar	8	5	12
Fifth instar	12	7	17
All nymphal instars	38.5	27	51

It is very unlikely that the maximum duration of each stage given above would ever be equaled by a single specimen passing through the successive stages, even in the laboratory during the summer months. It is, moreover, probable that under out-of-door temperature conditions the average duration of all nymphal instars taken together is a few days less than the average obtained by the laboratory observations.

This would seem to be the natural result of the insects being frequently exposed to direct sunlight. The average daily mean temperature during July at Tlahualilo was 81.5° F., and during August at Dallas was 82.8° F., the daily mean for the 2 months averaging 82.1° F. There is considerable variation independent of temperature. This is shown by specimens reared from the same egg-batch and kept in the same cage, having in every respect equally favorable opportunities for development. The range in duration of the stages becomes greater with each succeeding instar, which fact is well brought out by Table XVI.

Cold as a factor in retarding development.—At an average daily mean temperature of 69.4° F., the minimum length of the second instar among three specimens of the conchuela was 19 days, the period being from September 26 to October 15. In Table XVI is included a record of 7 days as the duration of this instar in one specimen. This represented the minimum length of the second instar among more than 10 specimens of the same brood. The period extended from July 20 to July 27, the average daily mean temperature being 77.9° F. A comparison of these two records plainly shows the effect of temperature on the duration of nymphal stages. Still greater retardation was exhibited by a lot of 31 fifth-instar nymphs of the conchuela, although the records are not as exact as those given, owing to the fact that the specimens were collected in the field and the entire length of the stage is consequently unknown. The specimens referred to were collected at Barstow, Tex., on October 13, and taken to the laboratory at Dallas, where they were confined in a wire breeding-cage out of doors, and supplied with fresh cotton bolls up to about the middle of November. From among these nymphs adults appeared on the following dates: October 17, 2; October 18, 1; October 19, 2; October 26, 3; November 3, 1. Nymphs were recorded as dead on the following dates: October 10, 5; October 14, 2; October 16, 1; October 26, 1. On December 19, 2 nymphs were still alive, although feeble and barely able to crawl, owing to lack of food. The average mean temperature at Dallas from October 15 to December 19 was 53.7° F., the October average being 62.9° F., November, 57.1° F., and up to December 19, 41° F.

LENGTH OF LIFE WITHOUT FOOD.

Like the adults, the nymphs of the conchuela, when deprived of food during the summer months, are short-lived. Nymphs in the first instar have been recorded as surviving as long as 5 days without food, which period is the longest ever noted under natural temperature conditions in any instance during the months of July, August, and September. On August 11, 46 nymphs hatched from a batch of eggs and all but 3 of these were dead from starvation on August 14,

none surviving after the fourth day. There seems to be little or no difference in the ability of nymphs in later instars to withstand starvation, so far as observed in all cases with summer temperatures, death taking place in from 2 to 4 days. Data in connection with the retarding influence of cold, given in the preceding paragraph, illustrate the effect of low temperature on the length of life without food of nymphs in the fifth instar. In an ice box with an average temperature of 48.6° F., the life of a nymph of the first instar has been prolonged to nearly 40 days without food. In the brood of 24 nymphs to which this specimen belonged, all were alive on the seventeenth day after being placed in the ice box; 18 alive on the twenty-third day; 10 alive on the twenty-ninth day; and only 1 alive on the thirty-seventh day. A third-instar nymph, robust, and apparently well fed previously, lived only 8 days in the ice box without food, the temperature as before averaging 48.6° F.

MOLTING.

As the time for molting approaches, a nymph becomes less active, ceases to feed, and shows a tendency to seclude itself where it will be less liable to interference by other individuals of the brood. A twig or other suitable object is tightly clasped, and the insect by pressure, exerted perhaps by means of air drawn into the trachea, splits the integument of the dorsum along the mesal line of the thorax, and in a line on each side of the head extending from the inner margin of the eye backward to the prothorax. The insect becomes freed from its old skin usually in the course of twenty or thirty minutes, although in one observation a conchuela in molting its fifth-instar skin required slightly over an hour. The insect as it emerges is pale pink and very soft, but gradually attains its normal color during the course of an hour. Adults remain soft to the touch for several days after molting. The molted skin which originally covered the abdomen shrivels, and, as is also the case with the integument which covered the thorax and head, only the black markings remain.

HABITS.

Nymphs.

FEEDING AND GREGARIOUSNESS.

For several hours after hatching, the young nymphs of the conchuela remain closely clustered either on or near by the egg-batch. If there are any unhatched eggs in the batch, the nymphs after a few hours' quiescence begin to feed on them, although it is probable that if such eggs contain nymphs they are dead or unable to hatch. Frequently enough food is contained in unhatched eggs of a batch to enable several nymphs to molt for the first time. For the most

part the nymphs are dependent on the juices of plants for food although eggs of their own and other species of insects are fed upon with relish wherever accident places them in their way. Except for this habit of feeding on insect eggs, the writer has never observed nymphs of the conchuela to attack living insects. In one instance, however, a nymph in the fifth instar exhibited a decided preference for animal food over vegetable. This nymph was in a cage in the laboratory with specimens of other species of Pentatomids, including a nymph in the fifth instar of *Podisus lineatus* H. Schf. This last-mentioned specimen died, but was not removed from the cage, and 24 hours later the nymph of the conchuela was observed feeding on the dead insect. As there was a fresh cotton boll in the cage, feeding on the dead insect was clearly a matter of preference.

The habits of nymphs on the cotton plant are much like those of the adults, except that the nymphs are less conspicuous, frequently being entirely hidden by the bracts of the bolls. They have a well-marked gregarious tendency, especially in the first three stages, during which all the surviving nymphs of a brood are usually found on the same boll. In a field at Tlahualilo, nymphs of the fifth instar occurred in unusual abundance in a field of cotton averaging 5 or 6 bolls over 1 inch in diameter per plant. The nymphs reached the plants by crawling, and at the time of examination while less than one-fourth of the total number of bolls were infested, as a rule, each infested boll had several nymphs clustered upon it. As many as 17 fifth-instar nymphs were counted on a single boll, while frequently from 5 to 15 nymphs were found on a single boll, with the plant otherwise free from the pest.

DISTANCE CAPABLE OF TRAVELING FOR FOOD.

The distance which nymphs of the conchuela are capable of traveling for food proved to be a matter of considerable importance at Tlahualilo in 1905, owing to an invasion by nymphs of vineyards, gardens, and cotton fields adjoining an alfalfa field where the insects were breeding in enormous numbers. The cutting of the alfalfa removed the food supply of the insects, thereby causing a migration in search of food.[a] The adults distributed themselves by flight, but the migration of the nymphs was limited by their capabilities for crawling. Few of the nymphs in the first 3 instars got beyond

[a] Migrations of this kind have not been previously unknown among the Pentatomidæ. Prof. D. A. Saunders in reporting an unusual outbreak of Uhler's green plant-bug (*Pentatoma uhleri*?) in South Dakota says regarding this point: "By the middle of June the bugs, being now about half-grown and their wings beginning to appear, began to migrate in great droves 'on foot' toward the cultivated fields. Mr. Senn estimates that they would make about one-half mile in a little less than a day across cultivated fields * * *." (Bul. 57, S. Dak. Exp. Sta., p. 39, Feb., 1898.)

the limits of the alfalfa field. The fourth-instar nymphs were found in abundance on fence posts, tree trunks, cotton plants, and weeds within 10 yards of the alfalfa field where they originated, and were scarce from 10 to 20 yards from this field. Nymphs in the fifth instar invaded a cotton field up to about 30 yards, in numbers estimated to average between ten and fifteen per plant; from 30 to 40 yards, between five and ten per plant; and from 40 to 60 yards, between two and five per plant. Few, if any, attained a distance of more than 60 yards from the point of origin. In these estimates due allowance has been made for the nymphs which occurred in the field before the beginning of the migration. These records do not show the maximum distance which the nymphs are capable of crawling, for the new food supply immediately adjoined the field of original infestation. It is certain, however, that this distance is over 60 yards.

Adults.

Fertilization.

Laboratory observations show that males of the conchuela are polygamous and females polyandric. During copulation in the cotton fields, both insects are usually engaged in feeding on a boll or other part of the plant. No attempt has been made to ascertain how long a pair of the insects remain in coitu, but in 2 instances a note was made of more than one-half hour or more than 2 hours, respectively. With other species of Pentatomid bugs, pairs have been observed in coition for a period of several hours at a time.

Egg laying.

Place of deposition.—Eggs are deposited in batches or clusters wherever the female happens to be feeding or resting. On cotton they have been found on both upper and lower surfaces of the leaf, though more commonly on the latter, also on bracts of bolls and on stems. In a cotton field at Llano, Tex., in September, 1905, a female conchuela was observed depositing a batch of eggs on lint in an open boll. On grape, 11 batches of eggs collected on July 12 were deposited as follows: 8 on underside of the leaves, 1 on the upper surface of the leaf, and 2 on the tendrils. Of 9 egg-batches collected on July 17, 4 were on the underside and 3 on the upper surface of alfalfa leaves and 5 on the underside of a solanaceous weed, the "trompillo" of the natives of Mexico. At Barstow, Tex., eggs of the conchuela with eggs of another Pentatomid which will be referred to later—*Pentatoma sayi* Stål—were frequently found on the seed-clusters of alfalfa, a favorite feeding place. In captivity the females of the conchuela, as well as other cotton-feeding Pentatomids, deposit eggs usually on the cotton bolls supplied for food, but occasionally on paper at the bottom of the cage and on the cheese-cloth cover at the top.

Number of eggs per batch.—The conchuela, in common with other members of the family Pentatomidæ, deposits eggs with considerable regularity in parallel rows, each egg except those in the outside rows being in contact with 6 others. The frequency with which eggs are deposited in multiples of 14 is strongly marked. A total number of 172 egg-batches of this species was deposited in the laboratory during these investigations. The total number of eggs in these batches was 4,900, or 28.4 eggs per batch. The number of eggs most frequently noted in single batches was 28, and the number ranking next in frequency was 42. The maximum number of eggs deposited in a single batch was 79.

Rate of deposition of individual eggs.—The intervals between the deposition of individual eggs in a batch, with midsummer temperature, varies from one minute to one and three-quarters minutes according to records made in the case of 2 females under observation while depositing eggs. The first of these specimens deposited 13 eggs in twenty minutes, 4 of which were deposited with one-and-one-half-minute intervals. The second specimen deposited 15 eggs in as many minutes.

FEEDING.

Part of plants preferred.—The conchuela shows a marked preference for the juices of the seeds and fruits of its food plants. In a report of preliminary investigations of this insect the writer recorded an observation regarding this preference. As no specific observation on this point has been made, it may be repeated that of 57 adults feeding on cotton plants, 43 were on bolls, 4 on leaves, and 10 on stems. The proportion feeding on bolls in this observation is less than ordinarily, as is incidentally shown by data given in another paragraph relating to proportion of time adults spent in feeding. The immature seed are the objective point of the insect's attack, as has been stated in describing the nature of the plant-bug injury. Rapidly growing bolls of medium size are preferred to large, nearly mature bolls, the lint of which offers serious resistance to the entrance of the threadlike mouth setæ. In connection with this preference bolls on the lower branches of the cotton plant are less subject to attack than are those growing on branches higher up.

Conspicuous position when feeding.—The conchuela is by far the most conspicuous of the Pentatomids destructive to cotton bolls which are discussed in this bulletin. This is as much so on account of its selection of a feeding place as on account of its size and striking color. This characteristic is an important factor under some conditions in the control of the pest in cotton fields, as will be explained in discussing remedial measures. The author's outline of field work necessitated the examination of many thousand cotton plants for the purpose of counting the insects which were found on them. From

this experience it is certain that in the cotton fields in clear summer weather fully 90 per cent of the conchuelas are visible to the observer from a standing posture and without moving any part of the plant. It was a rare occurrence, when making records of the kind indicated, that any additional specimens of these insects were found by using the hands to open up the plant. Only a few instances have been observed where the adult conchuela has been entirely or almost entirely hidden by the bracts of the cotton boll on which it was feeding. When feeding on a boll these insects generally occupy a position on the upper half. When resting, during bright sunlight, they are commonly observed in a conspicuous position on the cotton boll or on the upper surface of the leaves. The resting in the sun is usually observed during the forenoon.

Proportion of time adults spend in feeding.—In the determination of the amount of damage an individual conchuela is capable of inflicting in a cotton field it is important to know what part of its time it is engaged in feeding on cotton bolls. Observations were conducted both in the laboratory and in the field, and the results are summarized in the following tables:

TABLE XVII.—*Feeding records on the conchuela in the field, Tlahualilo, Durango, Mexico, July 22, 1905.*

Hours of observation.	Number of observations.	Number of conchuelas feeding on bolls.	Number of conchuelas crawling or resting on plants.	Per cent feeding on bolls.
9 a. m. to 12 m	251	142	109	56
1 p. m. to 5.30 p. m	66	51	15	77
Summary for day	317	193	124	66

TABLE XVIII.—*Laboratory feeding records on the conchuela, Lot A,[a] Series I, Tlahualilo, Durango, Mexico, July 20–22, 1905.*

Hours of observation.	Number of observations.	Number of conchuelas feeding on bolls.	Number of conchuelas not feeding.	Per cent feeding.
6.30 a. m. to 8.30 a. m	69	50	19	72.4
9 a. m. to 12 m	46	46	25	45.6
1 p. m. to 5 p. m	115	57	58	49.5
5.30 p. m. to 7 p. m	69	48	21	69.8
8 p. m. to 10 p. m	69	62	7	89.8

TABLE XIX.—*Laboratory feeding records on the conchuela, Lot A, Series II, Dallas, Tex., September 4–8, 1905.*

Hours of observation.	Number of observations.	Number of conchuelas feeding on bolls.	Number of conchuelas not feeding.	Per cent feeding.
6 a. m. to 12 m	47	8	37	17
1 p. m. to 6 p. m	24	9	15	37.5
7 p. m. to 10 p. m	24	15	9	62.5

[a] Collected in cotton fields in Tlahualilo between July 6 and 10.

TABLE XX.—*Summary of laboratory feeding records on the conchuela, Lot A.*

Place.	Time.	Per cent feeding in daylight.	Per cent feeding at night.	Per cent feeding, day and night.
Tlahualilo, Durango, Mexico	July 20-22,1905	59.4	89.8	74.6
Dallas, Tex	Sept. 4-8, 1905	27.2	62.5	44.8

A comparison of Tables XVII and XVIII shows a close correspondence between the laboratory and field observations on the amount of time the adults spend in feeding during daylight. The fact that in the field the conchuela feeds almost constantly after sunset has already been recorded.[a] We may safely assume that the adults feed for fully as large a percentage of the nighttime in the field as in the laboratory. Considering, therefore, that 90 per cent of the night (Table XVIII), and 66 per cent of the day, is spent in feeding, the percentage of the calendar day spent in feeding at the times and places of these observations was approximately 78.

Table XX shows a difference between the same lot of insects which is probably attributable to the difference in age of the specimens. Difference in temperature could have had no appreciable effect as it was slight, the average daily mean at Tlahualilo on the days of the observations being 76° F. and at Dallas 79° F.

Method of attack.—For locating the position for piercing the carpel of a cotton boll the conchuela makes use of its antennæ and tip of the rostrum. As in other Heteroptera, the rostrum is used only as a guide for the threadlike setæ and is never forced into the object upon which the insect may feed. As the setæ sink into the boll the rostrum bends at the joint between the first and second segments, being directed backward. The setæ at the same time are freed from the rostral groove of the basal two segments, and as these two segments fold together, this allows a greater depth of penetration. Next, the apical or fourth segment is bent or folded back leaving the setæ in the rostral groove only at the angle between the third and fourth segments. In this position the rostrum forms a letter "Z," the upper angle representing the joint between the second and third and the lower angle the joint between the third and fourth segments. Feeding may be continued with the rostrum in this position or the rostrum may be freed entirely from the setæ and directed straight back along the middle of the venter in the usual position it occupies when the insect is resting or crawling. The insect may therefore use practically the entire length of the setæ to penetrate through the carpel and the developing lint to the cotton seed. This length is about one-fourth of an inch. When feeding, the bug alternately

[a] Bul. 54, Bur. Ent., U. S. Dept. Agr., p. 26, 1905.

raises and lowers its head. After withdrawing the setæ from the boll, a downward stroke of one of the fore tibiæ places them in the rostral groove, each tibia for this object being provided with a short spine located on its inner side slightly beyond the middle.

Miscellaneous observations on feeding habits.—Twenty-six observations gave 20 minutes as the average time the adults fed through one puncture in a cotton boll. The maximum length of time in these observations was 1 hour and 30 minutes. In his report of preliminary investigations [a] on the conchuela the author presented his observations on the length of time adults remain on a single boll and on a single plant as follows: "One adult under observation in the field visited 4 bolls, 2 on each of 2 plants in 2 days, and remained for over 36 hours on the last of the 4 bolls. Another adult bug remained on the same boll for $2\frac{3}{4}$ days. Three remained on the same boll for over 30 hours and 3 others were found on the same plant 30 hours after they were first recorded. In none of these cases was it known how long the insects had been on these plants previous to their first being noted."

Abnormal predaceous and cannibalistic habits.—Starving adult conchuelas confined with live caterpillars of the bollworm (*Heliothis obsoleta* Fab.) and the cotton boll cutworm (*Prodenia ornithogalli* Guen.) failed to exhibit any indication of carnivorous habits. Dead or dying insects, however, are not always refused and are sometimes fed upon by adults as well as by nymphs in preference to cotton bolls. (See feeding habits of nymphs, pp. 41–42.) On a few occasions where 2 or more adults have been confined together in breeding cages, dead or dying specimens have been fed upon by the survivors of the lot. All evidence at hand goes to show that in the field the adult conchuelas are entirely phytophagous.

GREGARIOUSNESS.

The gregarious habit exhibited by the conchuela, like its habit of occupying a conspicuous position on the plant, is of considerable importance in its control. The author has previously noted [b] this striking feature, basing the records on observations made at a season of the year when these insects were comparatively scarce. Between August 31 and September 6, 1904, in a selected section of the cotton fields at Tlahualilo, 34 adults were collected on 16 plants, although the insects were so few that but 5 or 6 plants out of 100 were found to be infested. In July, 1905, 2 other species of Pentatomids (*Pentatoma sayi* Stål and *Thyanta perditor* Fab.) were found associated with the conchuela and occurring in moderate abundance on the

[a] Bul. 54, Bur. Ent., U. S. Dept. Agr., p. 26, 1905. [b] Loc. cit., pp. 26–27.

cotton plants. Field observations showed that whatever the nature of the attraction which is the basis of the occurrence, it is operative between the different species of Pentatomids as well as between individuals of the same species.

As a result of this gregarious tendency it was found that of 467 cotton plants examined on July 15, 1905, in one of the most heavily infested sections of the plantation at Tlahualilo, the infested plants, or those plants upon which there was at least 1 bug, numbered 91 and averaged about 2 bugs per plant. There were therefore about five times as many of the insects upon the infested plants as upon the average of the plants examined. A further concentration of these bugs was observed on the individual bolls. Of 100 bolls upon which one or more of the bugs was feeding 52 were found to have from 2 to 5 bugs each and 48 only 1 bug each. In all, there were 175 bugs feeding on the 100 bolls.

FLIGHT.

In September, 1904, conchuelas in the field showed themselves capable of only short flights, about 25 feet being the maximum distance attained by any one effort observed. In July of the following year observations showed these insects to be strong fliers. Gentle winds have little effect on the flight of the insects, as they seem to fly as often against as with the wind. Many of the insects have been observed to fly as far as the eye could follow. In one instance when lost to view the specimen was about 50 feet above the ground and gradually rising higher; in another case a specimen disappeared from view without rising higher than 15 or 20 feet.

The numbers of the insects in any given locality are subject to rapid changes owing to their flying propensities, but extensive migrations are always traceable to the need for a fresh food supply.

SEASONAL HISTORY.

INCREASE AND DECREASE IN NUMBERS DURING THE SEASON.

Previous to the season of 1903, as far as can be learned, the conchuelas attracted no particular attention as cotton pests in the Laguna district of Mexico. For the information here presented concerning the seasonal history of these insects in 1903 and 1904 the author is indebted to Mr. John Conduit, resident manager of the Tlahualilo cotton plantations, who, owing to the immense tract of cotton grown under his supervision, gives particular attention to cotton pests, and in addition to personal examinations in the fields directs the "bosses" of the various parts of the estate to send in to the office specimens of insects taken on the cotton plants, with information concerning their abundance. The bosses in their turn make examinations and send dozens of laborers into the various

subdivisions of the estate to search for any particular insect concerning which information may be desired at headquarters. This system made it possible to obtain accurate information concerning the abundance of the Pentatomid bugs here considered.

In 1903 the conchuelas were abundant only during the month of July and reached a maximum in numbers about July 20. Their first appearance was in the outlying districts, next to the mesquite, but they soon spread all over the cotton plantation, although they were more abundant in certain parts than in others. The insects disappeared early in August and did not reappear in noticeable abundance during the season, although the cotton plants remained green until October 17, when the first frost was recorded.

Although a close watch for the insect was maintained during the late spring and early summer of 1904, the first specimen was not taken in the field until July 6. During the following seven days a rapid increase in its numbers was noted, and on July 17 it was observed that a marked decrease had occurred. Nowhere on the plantation were the insects as abundant as in July of the previous year, nor were they so generally distributed.

On August 31 a personal examination in the cotton fields by the author showed the insects to be very scarce, although in certain sections of the plantation the open cotton bolls with stained and ruined lint gave unmistakable evidence of their greater abundance a few weeks earlier in the season.

In July, 1905, a detailed numerical study was made, which verifies Mr. Conduit's general observations for the two previous seasons. While the subject of natural enemies is discussed under a separate heading, it is necessary to mention here that the abundance of the conchuela during the season is principally dependent upon the efficiency of its parasitic and predaceous enemies. Egg-laying by the average individual is distributed over such a long period of time that it can hardly be said that the conchuelas naturally appear in broods. However, practically the same effect may be produced locally to a greater or less extent by the action of natural enemies. During the first two weeks of July adults and nymphs in all stages were found in abundance on mesquite in the uncultivated lands surrounding the Tlahualilo Cotton Plantation. The gradual ripening and drying of the beans was evidently causing a migration of the adults in search of food, many finding their way into the cotton fields. Egg-parasitism was acting as a practically complete check on further multiplication in the mesquite. In their search for food the first migrants from the mesquite settled in large numbers in sections of the plantation upon which *zoca* or seppa (stubble) cotton was growing, and later the migrants showed a preference for the planted

cotton when the bolls became more numerous and large enough to be attractive to them.

The most thorough study of the changes in the numerical status of the conchuelas during July, 1905, was made in a *tabla* comprising about 120 acres and known as "Ceceda A 14" (fig. 7). The cotton in this *tabla* was *zoca* or seppa, and during the first half of July repre-

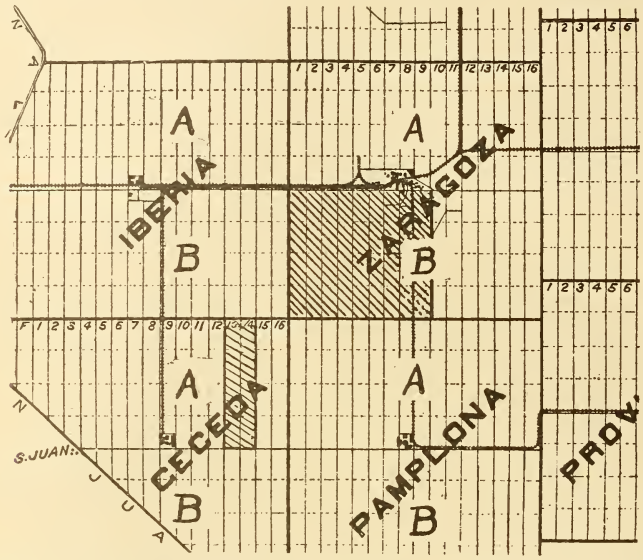


FIG. 7.—Diagram of a portion of the Tlahualilo Cotton Estates. The shaded *tablas* are the principal ones referred to in the text. (Original.)

sented conditions more attractive to the insects than did any equal area of *planta* (planted) cotton. Five examinations were made during July near the west end of this *tabla*, beginning with a row about 15 or 20 yards from the end and examining across the *tabla*, changing to next row east, every 10 plants. The results of this examination are summarized in the following table:

TABLE XXI.—*Variation in abundance of Pentatomids during July, 1905, at Tlahualilo, Durango, Mexico.*

When examined.	Number of plants per row.	Number of infested plants in 100.	Adults per 100 plants.			Total adult Pentatomids per 100 plants.	Number of nymphs *P. ligata* per 100 plants.[a]
			P. ligata.	*P. sayi.*	*Thyanta* sp.		
1905.							
July 11	100	19	52	0	0	52	0
15	99	30	52	3	2	57	1^{3} 1^{4}
21	98	31	59	4	0	63	2^{4}
27	103	12	33	0	0	33	0
29	96	7	17	0	0	17	1^{2} 1^{5}
Total	493	99	213	7	2	222	6
Average	98.6	19.8	42.6	1.4	.4	44.2	1.2

[a] Small figures indicate the instars.

Bugs were picked from the plants on this *tabla* between the examinations of July 11 and 15 and again between the examinations of July 27 and 29, the first pickings averaging about 7 per row and the second averaging between 5 and 10. The removal of these may be taken into consideration, although affecting the general results but little. The data obtained by these examinations show that conchuelas, or in a broader sense the Pentatomids, reached their maximum numbers in this field about July 20, and during the following week there was a decrease of nearly 50 per cent. Considering the picking just previous to the last examination, a continuance of the natural decrease in numbers is evident.

Following the same general plan, four additional examinations were made on July 15 for the purpose of showing the numerical status of the bugs on that date throughout the *tabla*. The length of the *tabla* being about one and one-quarter miles, five examinations were made, one at each end and three between, at places estimated to divide the *tabla* into fourths. Table XXII shows the data obtained by these examinations.

TABLE XXII.—*Numerical status of Pentatomid bugs in field of 120 acres, July 15, 1905.*

Examination No.	Number of plants in row.	Number of plants infested by adults per 100.	Number of adults *P. ligata* per 100 plants.	Number of nymphs *P. ligata* on 100 plants.[a]	Number of adults *P. sayi* per 100 plants.	Number of adults *Thyanta* sp. per 100 plants.	Total adult Pentatomids per 100 plants.
1	99	30	52	1^{3} 3^{4}	3	2	57
2	82	26	57	1^{2} 1^{5}	8	2	67
3	103	17	33	9^{2} 1^{4}	0	1	34
4	127	5.5	7.8	0	0	1	8.8
5	56	12.5	21.4	0	0	1	22.4
Total	467	91	171	16	11	7	189
Average	93.4	18.2	34.2	3.4	2.2	1.4	37.8

[a] Small figures indicate the instars.

As there were nearly 1,660 rows in the above *tabla*, it may be estimated from the data given that there were on July 15 approximately 60,000 conchuelas in the entire area of 120 acres.

Another series of observations made in *planta* cotton in Zaragoza B, *tablas* 1–9, also shows a diminution of the pest during the last 10 days of July. A single row was examined on each *tabla* about 200 yards from the east end, the rows running north and south.

TABLE XXIII.—*Abundance of Pentatomids, Zaragoza B, July 25, 1905.*

Tabla.	Number of plants in row.	Percentage of plants infested.	Number of adults *P. ligata* per row.	Number of adults *P. sayi* and *Thyanta* sp. per row.	Number of adult Pentatomids per 100 plants.	Number of nymphs *P. ligata* per row.[a]	Egg-batches *P. ligata.*
1	310	6.4	30	[b] 2	10.3	11 [2]	1
2	227	1.3	4	0	1.8	1 [2]	2
3	247	1.6	4	[c] 2	2.4	0	1
4	232	2.1	11	[c] 1	4.3	0	0
5	254	3.1	10	[c] 1	4.3	0	0
6	270	3.3	16	0	5.9	0	0
7	314	6.0	43	0	13.7	0	0
8	213	6.1	21	[b] 2	9.6	0	0
9	209	3.8	25	0	11.9	0	0
Total	2,276	.....	164	9	65.5	12 [2]	4
Average	255	3.7	18.2	1	7.3	1.33	.44

[a] Small figures indicate the instars. [b] *Thyanta* sp. [c] *Pentatoma sayi.*

TABLE XXIV.—*Abundance of Pentatomids, Zaragoza B, August 1, 1905.*

Tabla.	Number of plants in row.	Percentage of plants infested.	Number of adults of *P. ligata* per row.	Number of adults (Table XXIII) *P. sayi* and *Thyanta* per row.	Number of adult Pentatomids per 100 plants.	Number of nymphs *P. ligata* per row.[a]
1	301	3.0	13	0	4.3	1 [2] 0
2	236	2.1	6	0	2.5	1 [5] 0
3	265	1.1	3	0	1.1	1 [3] 0
4	308	1.0	3	0	1.0	1 [3] 1 [4] 0
5	303	3.9	10	2	4.0	2 [1] 1 [4] 0
6	275	1.1	3	0	1.1	0 0
7	371	.5	2	0	.5	0 0
8	232	4.3	18	0	7.7	25 [2] 1
9	170	1.1	3	0	1.8	0 0
Total	2,461	.....	61	2	24.0	33 1
Average	273.4	2.0	6.8	0.2	2.7	3.6 0.1

[a] Small figures indicate the instars.

The observations in Zaragoza B were made partly as a check on those made in Ceceda A, *tabla* 14. In the latter block a large percentage of the bolls had already been ruined and probably rendered less attractive as food for the bugs. There seemed to be a possibility that the decrease in numbers during the last 10 days of July was due to migration of the adults to other fields. In Zaragoza B, *tablas* 1–9, the cotton was in such condition on the average that it is improbable that a scarcity of suitable food supply could have impelled a migration. The data, moreover, on the numbers of eggs and nymphs found in the different *tablas* give strong indications that the infestation had progressed from *tabla* 1 toward 9 and that it had been, on the whole, recent. If the decrease in numbers of the adult conchuelas and other species of Pentatomids in Ceceda A, *tabla* 14, had been due to a migration, a similar decrease would have been unlikely to have occurred in the *planta* cotton in Zaragoza where the food supply was ample. The *planta* cotton in Ceceda A, *tabla* 16, separated from

tabla 14 by *tabla* 15 (which was planted in corn), showed on July 29 an average of between 2 and 3 adult conchuelas for each 100 plants. No actual estimates of the numbers of the insects present had been previously made, but from casual observation it is practically certain that the general decrease in numbers had occurred on this *tabla* as well as on the others examined. Other observations in various places confirm the belief that the diminution in the numbers of the insects occurred generally throughout the plantation. Messrs. J. P. Conduit and J. A. Vaughan informed the writer that after August 1 the bugs never appeared anywhere on the plantation in what seemed destructive abundance, although a few were constantly present in various sections. During the first week in December, no frost having occurred, the author could find no specimens of the conchuelas in the cotton fields, although within two weeks a live specimen had been seen at the gin, having been accidentally brought in with seed cotton.

The seasonal history at Barstow, Tex., in 1905, showed a similar record to that at Tlahualilo. The conchuela there was very abundant about the middle of July, and, while by no means uncommon on August 11 and 12, it was evident that a considerable reduction in numbers had taken place during the previous 2 or 3 weeks. On September 12 it was found that only a slight further reduction in the number of adults had taken place, but nymphs were comparatively scarcer. A month later Mr. J. C. Crawford, of the Bureau of Entomology, found that nymphs in the fourth and fifth instars were much more abundant than they had been on the dates of the two preceding examinations; the adults were slightly more abundant than on September 12, and mostly soft, indicating that they had recently matured. On November 14 Mr. Crawford, in a few hours' search where the bugs had previously been abundant, could find no nymphs and only a half dozen adults, all of which had attained the ordinary degree of firmness and were therefore not recently matured as were those collected on the preceding visit.

HIBERNATION.

The conchuela appears to hibernate exclusively in the adult stage. Observations have been recorded under the subject of duration of the nymphal stages which indicate that it is highly improbable that immature forms ever survive even one-half of the winter season. No field observations have been made upon the hibernation of this species owing to the fact that as cold weather approached the surviving adults were so scarce, even where they had been previously most abundant, that to obtain positive results more attention than it has been practicable to give would have been required. Nineteen

adults—10 females and 9 males—in confinement at the laboratory at Dallas furnished some data on the subject. Shortly after the middle of November no more food was provided and dead leaves were put in with the bugs in the lantern-globe breeding cages which were in an open shelter protected only from rain. The lot included a specimen (female) which became adult on August 14, and one which became adult on August 16 (male), 2 females which were collected at Clarendon, Tex., on September 19, and 8 males and 6 females collected at Barstow, Tex., on October 13. On December 1 all were alive; on December 19, when next noted, all were alive except one of each sex collected on October 13; on January 17 one of the same lot was observed crawling in a cage, the others being hidden in the leaves, while on March 8 an examination showed that 15 were dead and 4 had escaped during the writer's two months' absence from the laboratory. Whether or not these four specimens which escaped survived the winter is of course unknown, but as they left the cage after January 1 it may be presumed that they were more vigorous than the others. Perhaps in the field the bugs are capable of finding more suitable hibernating conditions than were provided.

In general, Pentatomids hibernate among dead weeds, in crevices under the loose bark of posts and trees, and in rubbish of various kinds. Uhler's green plant-bug is reported[a] to burrow in loose soil for the purpose of hibernating, and a similar observation[b] has been made in the case of the predaceous bug *Podisus serieventris* Uhl. Doubtless many Pentatomids, like other insects, attempt to hibernate in places where their chances of surviving the winter are slight, and it seems doubtful that Pentatomids which bury into the soil often survive the winter except where there is little or no rainfall.

Pentatomids are among the earliest insects to emerge from hibernation in the spring, although apparently only a small percentage passes the hibernating period successfully. Both sexes hibernate in many, if not in all, species. Regarding the appearance of the conchuela in the spring at Tlahualilo, Mr. J. P. Conduit, under date of March 10, 1906, in a letter to the writer says: "In spite of the cold weather we have had, the conchuela is still with us, and two or three live ones have already been picked up in various places." In northern Mexico and western Texas the first eggs are probably deposited shortly after the average daily mean temperature becomes constantly above 70° F. Ordinarily, this would occur early in April. The slow rate of production, however, in April and May temperature seems to prevent a large increase in numbers of the insects before June 1.

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[a] Bul. 57, South Dak. Exp. Sta., p. 40, 1898.

[b] The Gypsy Moth, by Edward H. Forbush and Charles H. Fernald, Mass. Board of Agr., 1896, p. 403.

DESTRUCTIVENESS.

INDIVIDUAL CAPABILITIES.

As a basis for determining the amount of damage done to cotton bolls by individual conchuelas an examination was made on July 17, 1905, of 104 bolls upon which one or more adults were observed feeding. These bolls were opened and the number of punctures found on the inside of the carpels was recorded. One hundred bolls showed positive injury, and the remainder did not show enough discoloration to justify their inclusion with those believed to be ruined, although the two smaller ones would very likely have failed to mature if left on the plants. These 4 bolls were in diameter approximately one-half an inch, three-fourths of an inch, one and one-eighth inches, and one and one-fourth inches, and showed on the inner side of the carpels, 2, 5, 19, and 32 punctures, respectively. The results of the examination of the damaged bolls are summarized in the following table:

TABLE XXV.—*Results of examinations of 100 bolls upon which one or more specimens of the conchuela had been observed feeding in the field.*

Approximate diameter.	Number.	Badly damaged.	Slightly damaged.	Total number of punctures.	Average number of punctures per boll.	Maximum number of punctures per boll.	Minimum number of punctures per boll.
Inches.							
½	1	0	1	3	3	3	3
⅝	7	7	0	119	17	34	15
¾	14	10	4	266	19	34	3
⅞	15	10	5	420	28	41	9
1	23	21	2	1,150	50	88	35
1⅛	28	20	8	1,484	53	141	22
1¼	8	5	3	504	63	136	8
1⅜	4	2	2	172	43	68	28
Totals and summary	100	75	25	4,118	41	141	3

Data have now been given from which we may calculate approximately the amount of damage that a single conchuela is capable of doing. It has been shown that in cotton fields in midsummer each insect spends on an average about 78 per cent of its time feeding on cotton bolls or in round numbers about 1,100 minutes per day. At the rate of 1 puncture for each 20 minutes while feeding, 55 punctures per day would be made by each adult of these insects. The average number of punctures (41) in the damaged bolls referred to in Table XXV is equivalent, therefore, to the number one adult may make in about three-fourths of a day.

Estimates based upon actual counts and examinations in various parts of Ceceda A, *tabla* 14, places the number of bolls about the middle of July in the entire *tabla* at a little over 2,500,000 and the number damaged by bugs at a little more than 1,125,000. Other

estimates which have already been referred to placed the number of conchuelas on the entire *tabla* at about 60,000. At the rate of one boll destroyed for each three-fourths of a day, it may be calculated that on July 15 the bugs had been in the field an average of 16 days each.

Estimates made after December 1, the details of which will be found elsewhere, placed the destruction by bugs in Ceceda A, *tabla* 14, at approximately 28 bales, not taking into consideration the bolls which were shed from the plants as a result of injury by these insects. The estimate of 60,000 conchuelas in the entire *tabla* was based on data obtained on July 15, after which there was a slight increase. Reference to Table XXVI will show that an estimate of 65,000 bugs is not too high for the maximum number of live conchuelas in this *tabla* at any time in July. For each 2,300 bugs, therefore, about one bale of cotton was destroyed. Considering the loss of one bale of cotton as equivalent to the moderate sum of $45, on the average each bug in the *tabla* destroyed cotton to the value of about 2 cents. This estimate can not be considered as representing even approximately the amount of damage by a single conchuela except under conditions similar to those described. General deductions of wider application may, however, be drawn from the data given.

From a comparison of the average maximum and minimum number of punctures per damaged boll in Ceceda A, *tabla* 14 (Table XXV), it is evident that the bolls were much fed upon by the bugs after they had received sufficient injury to result in complete destruction. Fortunately such feeding prevents a maximum amount of damage. The average of the ruined bolls of the various sizes with the minimum number of punctures is 15.4, or about one-third of the average number of punctures for all bolls. Even this number is greater than usually necessary for the destruction of bolls, as the data given show. On the other hand, many punctures are made in bolls which have reached such a stage of maturity that there results either no appreciable damage or only a staining of the lint to a greater or less degree.

The habit of the conchuelas of congregating on individual plants and even on individual bolls has a tendency to result in an excess of feeding punctures above the number necessary to cause destruction. Data have been given in Table III showing that at Dallas, Tex., in a field where plant-bugs were less abundant than in Ceceda A, *tabla* 14, at Tlahualilo, the average number of punctures per destroyed boll was 28. For convenience we may suppose that in a field infested by the conchuela, where the damaged bolls average 28 punctures per boll, it is desired to estimate the amount of damage the individual bugs may accomplish. At the average rate of 56 punctures per day, which is the estimated number, the bugs would have averaged 2

bolls per day destroyed instead of $1\frac{3}{4}$ bolls per day estimated in Ceceda A, *tabla* 14. As the percentage of damaged bolls increased, the daily damage per bug would diminish. If the increase in the number of new bolls was sufficient to prevent an actual increase in percentage of damaged bolls, the average daily injury for each bug would remain fairly constant at 2 bolls per day, and the ultimate damage, if in the same ratio as that which obtained at Tlahualilo in the field, to which the data refer, would be 60 per cent more than estimated for that field, or an equivalent of $3\frac{1}{5}$ cents for each bug.

From estimates made at Tlahualilo on the numerical status of the insects in July and on the percentages of ruined bolls in December, the relationship of the number of bugs present during the period of maximum abundance and the damage accomplished during the season may be presented in tabular form as follows:

TABLE XXVI.—*Relation of number of conchuelas to amount of damage.*

Field.	Number of adult conchuelas per 100 plants, July 23-25, 1905.	Number of adult conchuelas per row, July 23-25, 1905.	Average number of bales good cotton per acre.	Average number of bales ruined cotton per acre.	Percentage of ruined cotton.
Zaragoza B, *tabla* 1, east quarter	9.6	30	0.412	0.246	37
Zaragoza B, *tabla* 3, west quarter	1.7	3.5	.644	.11	14
Ceceda A, *tabla* 14, west quarter	46	46	.216	.221	50

The percentage of injury in Ceceda A, *tabla* 14, is so far above the ordinary that it may be properly considered as representing an extreme case, while the individual conchuelas, for reasons given, accomplished a minimum amount of damage, equivalent to about 2 cents. The maximum amount of damage for the individual conchuelas would be difficult to determine without a long continued series of observations, but it is probably equivalent to not more than 2 or 3 cents above the minimum amount. These estimates, while necessarily only approximating actual conditions, will serve to give a general idea of the damage an individual conchuela or other plant-bug is capable of causing. A knowledge of this point is an essential step in the determination of the practicability of various remedial measures.

REDUCTION IN YIELD OF INFESTED COTTON FIELDS.

As has been stated, the estimated loss to the cotton crop of 1903 at Tlahualilo was between 1,200 and 1,500 bales. Accordingly this loss for the entire acreage in planted cotton—amounting to about

19,000 acres—would average between 0.063 and 0.079 bale per acre. It is certain that this estimate was not too high, as it was based solely on the damaged and ruined bolls in evidence in the cotton fields at the close of the picking season and no consideration whatever was given to the bolls shed as a result of the injury by the insects. In the season of 1904 fewer of the bugs were present than in the preceding season and the average yield per acre of planted cotton amounted to 0.472 bale per acre, being an increase of 0.161 bale per acre. This increase is believed to be partly due to the difference in the number of bugs present in the cotton fields in the two seasons referred to.

In July and December, 1905, field observations throughout the plantation of over 22,000 acres at Tlahualilo gave data from which it is believed an estimate of damage has been made which is more accurate than any estimate of insect damage based on actual field examination ever attempted for as large an acreage. It was found that bug damage ranged from none at all in restricted areas to 31.6 per cent and for the entire plantation averaged very close to 8 per cent. This does not include the bolls which were shed from the plants. These numbered probably less than 2 per cent and their loss was not necessarily detrimental to the crop as they did not, like those damaged bolls that persisted, continue to receive nutriment from the plant. The entire yield at Tlahualilo in 1905 amounted to about 15,000 bales. The loss of about 8 per cent represents, therefore, about 1,200 bales of cotton. The methods used in the examinations upon which this estimate is based will be explained hereafter.

A striking contrast to the conditions at Tlahualilo was observed about 40 miles distant in the southwestern portion of the Laguna district near the cities of Gomez Palacio and Lerdo. Here, for some obscure reason, persistent search failed to show the presence of the conchuela while other plant-bugs were of remarkably rare occurrence in cotton fields. As a consequence plant-bug injury was difficult to find and, at the most, amounted to only a small fraction of 1 per cent.

The most detailed study of the losses due to plant-bugs was made at the Tlahualilo plantation in 4 blocks heretofore referred to, namely, Ceceda A 14, Zaragoza B1, Zaragoza B2, and Zaragoza B3. In the first the work extended throughout the block while in the last 3 blocks the studies were local and represented in each case conditions which may have been characteristic of only a small part of the entire block of 120 acres. In July, 1905, many examinations of green bolls were made for the purpose of determining the percentage of damage,

but later it was shown that data of this kind obtained at that season of the year were of little significance. Thus in one locality as high as 70 per cent of all bolls in July were ruined by plant-bugs while later increases in the number of bolls and decreasing destructiveness of the insect lowered the percentage of damaged bolls to about 31.

Method of estimation of losses.—Final estimates of the losses due to plant-bugs at Tlahualilo were made during the first week in December, 1905. Growth of the bolls had practically ceased, although no frost had occurred. Many green bolls had attained a mature size and in all probability would open under the influence of the first frosts. Estimates for each section of a field were based on exact counts and the classification of all bolls on 25 plants of a row, selecting 5 consecutive plants at each end and 3 groups of 5 consecutive plants each, at points between the end groups, to equitably represent the entire row. The bolls produced by each plant were classified as unopen, empty burrs, perfect bolls, slightly stained, badly stained, and destroyed. Included in this estimation as unopened were only such bolls as had reached mature size and were likely to open and produce good lint when not injured by insects. "Empty burrs" indicate that from these the lint matured and was picked or had fallen out. In either case as far as this investigation is concerned these should be associated with the perfect bolls. Classed as perfect bolls were only those which showed no trace of noticeable stain due to plant-bug attack. Included as slightly-stained are those which plainly show stain, although probably worth picking in the sense that the increased bulk gained thereby would probably offset the possible decrease in value per pound due to the stain. "Badly-stained" bolls contained no lint that could be profitably picked, although not more than one lock in any boll or about 10 per cent of all locks in this class was actually destroyed. "Destroyed bolls" included no lint that a picker would often intentionally pick, and were characterized by open or partly-open carpels showing a discolored, matted mass of partially developed lint in at least two locks of each boll, with any locks not thus affected badly stained and damaged sufficiently to prevent "blowing." Classification as regards the last four grades was in many cases necessarily a matter of personal opinion, but in averaging it is believed this feature is largely eliminated, as on the whole the differences are quite distinct. Bolls damaged by boll-worms are omitted from these considerations.

Damage to cotton in Cecelia A, No. 14.—Five examinations were made according to the methods described above. One was about 50 feet from the east end, 1 about the same distance from the west end, and 3 at points dividing the block into 4 approximately equal

parts. The results of these 5 examinations of 25 plants each are summarized as follows:

TABLE XXVII.—*Classification of bolls on average plant, Ceceda A 14, with reference to plant-bug damage.*

Examination No.	Unopen.	Empty burrs.	Perfect, open.	Slightly stained, open.	Badly stained, open.	Destroyed.
1	9.6	1	9.56	3.48	5.2	8.12
2	13.7	4.4	22.3	5.72	7	7.52
3	10.6	3.8	16	6.2	6.5	10
4	11.3	1.68	13.2	5.4	5.4	7.5
5	7.6	1.92	10.6	9.4	7.1	7.2
Average....	10.56	2.56	14.33	6.04	6.24	8.07
Per cent....	22.1	5.3	30	12.6	13	17

The average number of bolls per plant throughout the block according to the above data is 47.8. Data previously collected showed an average of 93 plants per row in this block which consisted of about 1,660 rows. There were accordingly in round numbers 154,000 plants in the block and about 7,370,000 bolls.

Tests by officers of the Tlahualilo plantation showed that the cotton grown at that place averaged about 63 bolls of seed cotton per pound. It can be readily calculated from this data that if all the bolls in the block produced good lint there would be a yield of approximately 78 bales for the 120 acres in the block. These bolls and their equivalents in bales of cotton are here given in tabular form.

TABLE XXVIII.—*Classification of bolls in entire block, Ceceda A 14, with reference to plant-bug damage.*

Classification.	Estimated number of bolls.	Number of bales of cotton represented.
Unopen	1,629,000	[a] 16.37
Empty burrs	391,000	4.13
Perfect and slightly stained, open	3,139,000	33.23
Badly stained, open	958,000	[b] 9.13
Destroyed	1,253,000	[c] 15.25
Total	7,370,000	78

[a] An examination showed that about 5 per cent of unopened bolls were ruined by plant-bugs; consequently 0.86 bale has been deducted from the number of bales represented.

[b] About 10 per cent of the total number of locks in badly-stained bolls were destroyed; consequently 1.01 bales were deducted.

[c] Including 0.86 bale, or 5 per cent, of unopen bolls (see note [a]) and 1.01 bales, or 10 per cent, of badly-stained bolls (see note [b]).

According to the writer's estimate, the maximum possible yield in this block would be 78 bales, less the number of bales represented in the above table by the empty burrs and the destroyed bolls. This gives 58.73 bales or 0.49 bale per acre. The actual yield as finally recorded at the office of the Tlahualilo Company was 55 bales for the block or 0.46 bale per acre.

Regardless of the amount of cotton ginned, in computing the actual destruction we should include the badly-stained bolls with the destroyed bolls. A considerable part of the badly-stained cotton is regularly left by pickers on account of its being imperfectly opened out and not easy to handle. Furthermore, as will be shown in discussing the effect of plant-bug injury on the quality of the lint, the picking of such lint is a distinct disadvantage, probably more than offsetting the increased weight attained. In Ceceda A, No. 14, therefore, the actual loss in 1905 may be considered to be equivalent to about 24.38 bales, or 0.2 bale per acre.

Damage to cotton in Zaragoza.—Three examinations were made in Zaragoza, one in each of the first 3 blocks, following the plan heretofore outlined of examining 25 plants per row. The data obtained represent local conditions only and do not necessarily indicate either the damage or the yield throughout each block. It should be noted, however, that the final yield of the 360 acres comprising the 3 blocks was 187 bales, whereas the examinations from which the data in the following table were obtained would indicate a yield of 193 bales.

TABLE XXIX.—*Local examinations in Zaragoza with reference to cotton damaged by plant-bugs.*

Block.	Bolls not ruined.					Bolls ruined.				Unopen bolls.
	Lint picked and fallen from burrs.[a]	Perfect.	Slightly stained.	Total.	Equivalent bales per acre.	Badly stained.[b]	Destroyed.	Total.	Equivalent bales per acre.	
Zaragoza B 1 (east end)	*Per ct.* 39.56	*Per ct.* 16	*Per ct.* 6.7	*Per ct.* 62.26	0.49	*Per ct.* 9	*Per ct.* 17.14	*Per ct.* 26	0.174	*Per ct.* 11.7
Zaragoza B 2 (east end)	24.98	15.4	11.3	51.68	.521	13.2	19.92	33	.255	15.4
Zaragoza B 3 (west end)	63.5	10	5	78.5	.61	3.7	11	14.7	.11	6.3

[a] Deducting 2.44 per cent, representing approximately the number of ruined locks present in empty burrs.
[b] Adding 2.44 per cent of ruined locks present in empty burrs.

EFFECT OF PLANT-BUG ATTACK ON QUALITY AND MARKET VALUE OF LINT.

The market value of each bale of cotton is determined by examination of samples of the lint by experts who judge of its relative quality. This grading of the staple limits the use to which each bale may be put. Stained cotton is the least desirable of all grades and generally brings a selling price of about 50 per cent of the average unstained grades. Tables XXVII and XXIX are illustrations of instances wherein the percentage of slightly-stained cotton has been determined in the field. This class may include as many of the entire number of bolls as 11 per cent, or 17 per cent of the lint picked, omitting bolls completely ruined. It is obvious that such inferior material reduces the value of the better grades with which it may be mixed.

At Tlahualilo the crop of 1902–1903 included 1,277 bales of cotton, or 11.2 per cent, grading below "strict good ordinary," and classed as "stained." The crop of 1903–1904, which was damaged by bugs to greater extent than any other crop, included 1,812 bales, or 23.5 per cent, of this class of cotton, while the crop of 1905–1906 included 885 bales, or 6.6 per cent. Near the cities of Lerdo and Gomez Palacio, in another section of the Laguna district, as has been heretofore stated, the conchuela was apparently entirely absent and other Heteropterous insects were of exceptionally rare occurrence in cotton fields. Stained cotton in the fields in this locality is either difficult or impossible to find. A plantation near Lerdo, belonging to the same company as the one at Tlahualilo, produced over 2,000 bales of cotton as the crop of 1905–1906. The author's field observations as to the absence of plant-bugs and stained cotton in these cotton fields in July and December, 1905, received verification in the classification of baled cotton by the buyers, inasmuch as not a bale of the entire crop was classed as "stained."

NATURAL CONTROL.

Weather Influences.

Hard rains doubtless destroy many young Pentatomid nymphs, but such rains seldom occur in the regions where the conchuela is most abundant. At Tlahualilo, after an unusually heavy rainfall in July, 1905, Mr. J. A. Vaughan found nymphs in large numbers crawling on the ground along the banks of an irrigation canal several miles from the cultivated fields. These nymphs were mostly in the fifth instar and had undoubtedly been beaten from the mesquite by the rains. Two results of importance might follow such an occurrence: First, a large number of the nymphs might die without reaching food; second, the nymphs thus forced to migrate might overrun cultivated lands with serious effect upon the crops.

Parasites Attacking Eggs.

The writer has recently described as *Telenomus ashmeadi* Morrill (fig. 8; Pl. V, fig. 2), an important species of egg-parasite which has been found, both in western Texas and in Mexico, to effectively check the multiplication of the conchuela by midsummer.[a] The seasonal history during several years as noted by reliable observers indicates that this result is accomplished with considerable regularity. Were it not for these insects, damage to cotton at points in the Laguna district in Mexico and western Texas would be so great that this crop could not be profitably produced. The importance of these insects in western Texas in 1905 has been discussed by the writer in a previous bulletin[b] and their general economic importance and their life

[a] American Naturalist, XLI, pp. 417–430, 1907.

[b] Bul. 64, Pt. I, Bur. Ent., U. S. Dept. Agr., pp. 9–10, 1907.

history and habits treated of in connection with the description of the species.

The following table summarizes the data on parasitism by *Telenomus ashmeadi* obtained during the season of 1905:

TABLE XXX.—*Parasitism of eggs of the conchuela by Telenomus ashmeadi in 1905.*

When collected.	Locality.	Egg-batches.		Eggs.		
		Number collected.	Number parasitized.	Number.	Per cent from which parasite emerged.	Per cent from which bugs hatched.
1905.						
July 7	Tlahualilo, Durango, Mexico	2	2	75	77.4	0
July 12	do	9	7	229	75.0	22
July 17	do	11	9	490	49	21
August 11-12	Barstow, Tex	6	5	181	[a] 22	19
September 12	do	13	13	246	54	8
Summary		41	36	1,221	55.5	14

[a] Fifty-one per cent contained parasites; 25 per cent failed to emerge.

As stated by the writer in previous publications, the percentage of eggs from which adult parasites emerge does not indicate necessarily the number of bug eggs which are actually prevented from hatching by these beneficial insects. Both in the laboratory and in the field many parasites reach maturity, but for some unknown reason fail to emerge. In many cases the parasites make holes with their mandibles in the egg-shells of the bugs in which they are incased, nearly large enough to permit of escape, and then die, apparently becoming exhausted by their efforts. Other eggs in parasitized batches fail to hatch, or produce adult parasites, containing nothing but a shriveled, brownish, and structureless mass. The failure of such eggs to produce nymphs seems to be usually due to parasitism. Possibly in such cases the larva of the parasite died soon after having accomplished the destruction of the host egg. The table leaves unexplained the failure to hatch of about 30 per cent of

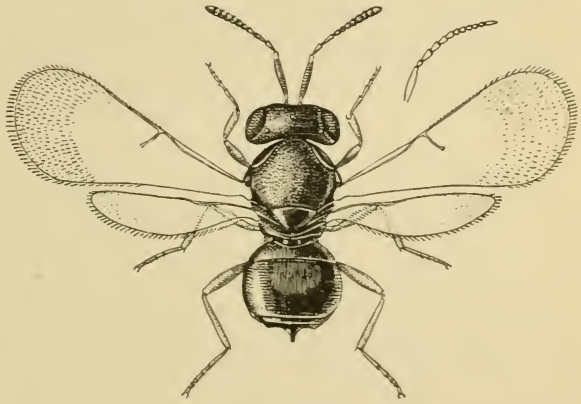

FIG. 8.—*Telenomus ashmeadi*, an important egg parasite of *Pentatoma ligata:* Adult female and antenna of male. Highly magnified. (Author's illustration.)

the total of over 1,200 eggs collected in the field. Of 156 eggs, representing the five batches collected in the field from which no parasites were reared, only 1 egg failed to hatch. It has been stated that in the laboratory all but about 7 per cent of fertile eggs hatched. Even allowing for eggs destroyed by predaceous insects and the small percentage which normally fails to hatch, it is evident that the total percentage of conchuela eggs destroyed by Proctotrypid parasites is from 15 to 25 per cent above the percentage shown in the table from which parasites actually matured and emerged.

Parasites Attacking Adults and Nymphs.

The only parasite of the conchuela attacking the adults and nymphs which has come under the writer's observation, is the Tachinid fly *Gymnosoma fuliginosa* Desv. (Pl. III, figs. 9, 10). The female of this species deposits her eggs on the adults and nymphs in the fifth nymphal instar, usually near the margin, on the anterior half of the body (Pl. III, fig. 9). So far as observed, the percentage of these bugs which are parasitized by this fly is not large. Observations at Tlahualilo, Mexico, and at Barstow, Tex., in 1905, indicated that it was never more than 5 per cent. Under favorable conditions these Tachinid flies might attain a high degree of usefulness, but it is probable that they seldom exert much influence toward the reduction of the numbers of the conchuela and other Pentatomid pests.

Predatory Enemies.

invertebrates.

No one of the invertebrate enemies of the conchuela or of other Pentatomids has, in the writer's experience, shown itself to be of any great importance. Taken together, however, they form a group entitled to consideration.

Attacking eggs.—Nymphs of other species of Pentatomids as well as of the conchuela itself may destroy eggs in the field. The only species observed actually engaged in feeding on unhatched eggs of the conchuela is *Thyanta custator* Fab., the specimens being in the fifth instar. The well-known predaceous Anthocorid, *Triphleps insidiosus* Say, doubtless is as fond of the eggs of Pentatomids as of the eggs of other insects. The same may be said of the larvæ of various species of Chrysopa, although specific observations have not been recorded in either case. It is not uncommon to find the remains of eggs of the conchuela which have the almost unmistakable appearance of having been destroyed by predatory insects provided with mandibles. Entire batches consisting of as many as 14 eggs have been found in this condition with the circumstances indicating that a single insect had been responsible for the destruction of each batch. It is probable

that the insects concerned in this work were either Coccinellid beetles or ants. As regards insects of the former group, there is no direct evidence of their connection with the destruction of eggs mentioned, but in a cotton field a small undetermined ant has been observed to work assiduously for several minutes attempting to separate an egg from a batch. This observation gives basis for the supposition that various species of ants are somewhat beneficial as destroyers of the eggs of Pentatomid pests. The destruction of eggs by any of the insects mentioned is not always productive of the best results, for it is possible, and in some cases probable, that a large part of the number thus destroyed might have produced adult Proctotrypid parasites, the great value of which has been discussed.

Attacking nymphs.—Even newly-hatched nymphs of the conchuela, as well as most other Pentatomids, are provided with glands which produce offensive volatile fluids. The value of such secretions as protection against spiders and predaceous insects is problematical. Predaceous Pentatomids are cannibalistic in many cases, and it is not to be presumed that such insects discriminate between the flavor of their own and other species. The writer has observed a nymph of *Podisus maculiventris* Say attacking a much larger nymph of *Euschistus fissilis* Uhl.—both species of Pentatomids which give off disgusting odors when disturbed. Only one predaceous Hemipteron (*Zelus renardii* Kol.) has been observed to feed on the nymphs of the conchuela. This has so far been observed only in the laboratory, but the circumstance indicates that it is of frequent occurrence in the field. This Reduviid is common in the cotton fields in both Texas and Mexico, and the nymphs not only voraciously attack one another but any other insect which crosses their path. The adults frequently capture and suck the juices from bees of various kinds which visit the cotton blooms. In confinement an adult destroyed 4 nymphs of the conchuela within 24 hours. Nymphs of the Reduviid readily attack nymphs of the conchuela, and one specimen of the former was reared to maturity with its diet limited to nymphs of the Pentatomidæ. Many other species of Reduviidæ are commonly found in cotton fields and doubtless may be relied upon to destroy a small percentage of the nymphs of injurious Pentatomids.

Among other orders of insects the author has but one record of predaceous forms attacking nymphs of the conchuela. A larva of an unknown Syrphid fly on a cotton leaf, supplied as food to nymphs of the conchuela in the second instar, quickly destroyed two of the young bugs. Credit for this observation is due Mr. W. W. Yothers of the Bureau of Entomology.

Nymphs of the conchuela have been found on cotton plants enmeshed in spider webs, but spiders have never actually been observed feeding on this Pentatomid, although an immature spider about one

and one-half millimeters long, shortly after being brought into the laboratory from a cotton field, killed and partially ate a first-instar nymph of a Pentatomid of the genus Thyanta.

Attacking adults.—No invertebrates are known to attack adult conchuelas, nor has the writer found any reference on this point in the case of other Pentatomids. Broken and empty shells of adults have been found in cotton fields in midsummer, but there is no direct evidence to show this to be the work of predatory enemies, although it may be suspected.

BIRDS.

In spite of much evidence to the contrary, scattered in various scientific publications, it is the prevalent idea that the offensive odor of bugs protects them from birds. Without this supposition the object and origin of the odoriferous glands may be difficult to explain, but studies in the feeding habits of insectivorous birds has shown that in most cases Pentatomid bugs are eaten at least to the extent of the proportion of their numbers to the numbers of other insects of the same and larger size. Further, it would seem that some birds, like the crow, possess a predilection for insects of pungent or otherwise strong taste or odor. Careful studies have been made of the feeding habits of about 20 common American birds. Almost without exception Pentatomids (variously referred to as "stink bugs," "soldier bugs," and "Pentatomids") are included in the diet of each of these birds, amounting on the average to about 3 per cent of all the food.

Thus far no specific observations have been made for the purpose of determining the extent to which birds feed upon the conchuela. It is evident, however, that there is some important influence combined with egg parasitism to produce in midsummer the marked reduction in number of these insects observed both in Mexico and in Texas. The egg-parasites effectually check the multiplication of the pest after the month of July, but the diminution in numbers of the adults remains unexplained. In the laboratory, protected from their enemies, the life of the adult conchuela extends over many weeks, 27 specimens collected at Tlahualilo between July 6 and July 10 averaging over two months each.

It is inconceivable that the difference between field and laboratory conditions should be so great that, of the insects of the field on July 10, over 60 per cent should die from natural causes before August 1, while in the laboratory less than 5 per cent should die during the same period. Furthermore, if the numerical decrease in question had been due to natural exhaustion of vitality of the adult insects, it would be expected that many dead specimens would have been found in the cotton fields. As a matter of fact, dead specimens were exceedingly rare and the few found gave evidence of having been

destroyed by some enemy rather than of having died from natural causes. As has been shown, the decrease in number is a general and not a local occurrence, and it takes place without regard to the abundance of food. These circumstances seem to point to the strong probability that birds are the useful agents in the reduction of the numbers of the adults of the conchuela.

ARTIFICIAL CONTROL.

Under the heading, "Artificial control," will be discussed only those measures which have little or no application except for the conchuela, together with such measures as have been the object of especial observation during the observation of that pest.

PREVENTIVE MEASURES.

Clearing land of mesquite.—As a means of obviating in a large measure the destruction by the conchuela, the prevention of spring multiplication of the pest on mesquite in the vicinity of cotton fields is of prime importance. Near Llano, Tex., Mr. J. C. Crawford, of this Bureau, on September 3, 1905, found an excellent example of the conditions which may result from the neglect of a breeding place of plant-bugs. As would be expected from its previous history elsewhere, the conchuela was in comparatively small numbers at that season of the year, but associated with it were two other plant-bugs, which will be treated later, *Largus succinctus* L. and *Nezara hilaris* Say. These three pests were breeding on a group of about 4 or 5 mesquite, located just outside of the cotton field. In the cotton field the damage to the bolls and the abundance of the plant-bugs in the section close to the mesquite, as compared with other parts of the field, gave almost conclusive evidence that the presence of the trees mentioned was largely or entirely responsible for the conditions found. In this and similar cases, therefore, the removal of the mesquite would unquestionably result in considerable benefit to the cotton, repaying the trifling cost many times over in a single season.

Under conditions such as those at Tlahualilo, where the cotton and surrounding mesquite land are under the same management or ownership, the policy should be adopted of removing, as fast as practicable, the mesquite, which experience has shown to be an element of danger. Where farms are comparatively small and a diversity of crops is grown, as at Barstow, Tex., the results might not be as striking as elsewhere, but concerted effort among landowners toward the eradication of mesquite growing in and around cultivated lands is recommended.

Prevention of excessive multiplication on alfalfa and other plants.—In addition to mesquite, alfalfa is the only other food plant which has thus far shown itself likely to harbor the conchuela in numbers

which might prove disastrous to cotton. Various grains, however, will also bear watching for the purpose of locating and treating cases of excessive multiplication. In a previous paper, dealing with the conchuela at Barstow, Tex., in 1905, the author considered at length the subject of the control of this insect in the alfalfa fields, a brief recapitulation of which will suffice in this connection.

At both Tlahualilo and Barstow, in 1905, were notable instances of the development of enormous numbers of the conchuela in alfalfa fields. At the former place the bugs derived their entire food supply from the stems and leaves of the plants, while at the latter locality more than ordinary multiplication occurred only where an attempt was made to produce a crop of seed before the middle of August. The advantage is in favor of the crop used only for forage, for the shorter time between the cuttings permits of the maturity of but comparatively few of the insects, and the problem to be solved consists of the treatment of the nymphs and the prevention of their migration to neighboring cotton fields. An uncut border a few feet in width around an infested alfalfa field will serve to trap the crawling insects which then may be destroyed by spraying with a strong solution of kerosene emulsion. If heavy infestation be restricted to limited areas of the field, hand picking of the adults by children or other cheap labor and destroying the nymphs by spraying may be advisable. Gasoline blast torches have been used for destroying the conchuelas and may sometimes be useful under circumstances where no vegetation except weeds or other noxious plants will be affected. The longer period required for the maturity of a seed crop of alfalfa, together with the abundance of favored food (alfalfa seed), affords most favorable conditions for the development of countless numbers of the conchuela. Great care should be exercised, therefore, wherever this pest is likely to occur in destructive numbers, in selecting a season of the year when a seed crop of alfalfa can be grown profitably and without disadvantage to cotton or other neighboring crops. In western Texas an attempt to produce a seed crop has been shown by past experience to be practicable only after the middle of August, when the destructive season of the conchuela has passed.

Field Measures.

HAND-PICKING.

Extent of experiments and methods used.—In cooperation with Mr. J. P. Conduit and Mr. J. A. Vaughan, manager and assistant manager, respectively, of the Tlahualilo plantation, experiments were conducted in July, 1905, for the purpose of determining the utility of hand-picking as a practical remedial measure against the conchuela. In this work many native boys ranging from 9 to 15 years of age were employed.

These worked on different sections of the plantation and in several gangs of from 6 to 50 boys each, the work of each gang being under the direct supervision of a man selected for the purpose from among the laborers. The time possible for the author to devote to this phase of the investigation of the conchuela did not permit of as detailed a study as was desirable, yet it is believed that the experiments are by far the most extensive ever conducted along the line of hand-collecting of insect pests.

After testing various receptacles for containing the bugs as they are collected in the field, a dipperlike tin vessel, with a cover consisting of a detachable funnel, was devised[a] and found to serve the purpose in an ideal manner. The constructive details of this receptacle are shown in figure 9. A slight jar of the boll or leaf upon which the bug is resting is sufficient to cause it to fall through the funnel into the chamber below, from which there is practically no chance for its escape until the receptacle is filled to the opening. The contents should then be emptied into a pail containing a mixture of water and kerosene in the proportion of two-thirds to one-third, respectively.

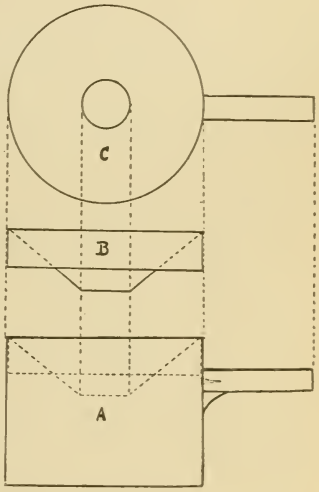

FIG. 9.—Plan for the construction of a collecting can for use in hand-picking cotton plant-bugs: A, Main part of can, made of tin and with a wooden handle; B, funnel-shaped cover; C, vertical projection showing cover with opening in the center and vertical projection of handle at right. (Original.)

Results of experiments.—The removal of many thousands of the conchuela from the cotton fields could not have other than direct beneficial results while, as an experiment, useful information concerning the practice of hand-picking of plant-bugs was obtained.

The greatest obstacle to be overcome in order to obtain the best results from hand-picking was found to be lack of thoroughness. There was much variation, however, in regard to this point and it was soon evident that it is dependent almost entirely upon the efficiency with which the boys engaged in picking the bugs were supervised. A series of examinations was made in two *tablas* of 120 acres each for the purpose of determining the number of bugs present on the plants before and after picking. It was found that in one *tabla* about 21 per cent, and in the other about 33 per cent, had been removed. From the fact previously stated that in clear weather fully 90 per cent of the bugs occupy conspicuous positions on the plants it is evident that the lack of thoroughness in the above-mentioned

[a] Credit is due Messrs. Conduit and Vaughan for their ideas in this connection.

instance is no argument against the effectiveness of the operation. Moreover, it will be shown that the advantages derived from the removal of a third or even a fifth of the insects from the plants amply repaid the expenditure.

An exact count gave approximately 775 bugs to a pint; this was used as a basis for estimating the number of conchuelas picked. The average number of bugs picked per boy per hour varied, according to the abundance of the insects and the efficiency of the supervision, from 8 to 85. As it was not considered advisable to teach the boys to distinguish between even such widely different insects as grasshoppers and Pentatomid bugs, insects were collected indiscriminately.[a] The list of insects found in a lot thus captured on July 12 gives an idea of the comparative abundance of the principal conspicuous and most easily captured insects in a cotton field. Unless otherwise stated the insects in the following list are adults.

List of insects captured in a hand-picking experiment in a cotton field at Tlahualilo, Mexico.

	Number.	
Hemiptera	3,753	
Pentatoma ligata Say (conchuela).		
Adults		3,637
Nymphs		75
Thyanta sp.		16
Pentatoma sayi Stål. (grain bug)		5
Largus succinctus L.		15
Oncopeltus fasciatus Dall		3
Lygæus turcicus Fab.		2
Coleoptera	250	
Epitragus sp.		200
Allorhina nitida L. (fig-bloom beetle)		45
Hippodamia convergens Guér. (lady-beetle)		5
Orthoptera	17	
Brachystola magna Gir. (lubber grasshopper)		16
Gryllus sp. (cricket)		1
Lepidoptera	4	
Deilephila lineata Fab. (white-lined sphinx) larvæ		2
Estigmene acræa Dru. (salt-marsh caterpillar)		2
Hymenoptera	1	
Bombus sp. (bumblebee)		1
Total		4,025

Cost of hand-picking.[b]—In Table XXXI specific examples are given showing the cost of hand-picking of the conchuela in its relation to the numbers of the insects obtained.

[a] In estimates of the number of conchuelas based on bulk at the rate of 775 per pint, due allowance was made for the space occupied by other species of insects.

[b] In referring to cost in Mexico, equivalents in the United States currency are used.

TABLE XXXI.—*Cost of hand-picking of the conchuela.*

Date.	Number of boys employed.	Total number of hours.	Number of conchuelas collected.	Average number of conchuelas per boy.	Expense of picking.	Number of bugs destroyed for each cent of expense.
1905.						
July 12	4	20	729	182	$0.50	14.5
July 13	14	70	6,200	428	2.25	27.5
July 14	22	110	5,400	227	3.25	16.6
July 25	25	125	1,500	60	3.50	4.3
July 26	25	125	1,600	65	3.50	4.6
Summary	90	450	15,429	171	13.00	11.+

On July 25 and 26 the work in the *tabla* to which the above data refer was unsatisfactory, owing to incompetent supervision. Accepting, however, 11.+ as the average number of bugs collected and destroyed for each cent of expense for a total of $135 expended in 1905 for hand-collecting at Tlahualilo, it is estimated that approximately 180,000 of the insects were collected and destroyed. If each of these insects at the time of its removal from the field had been capable of causing one-half as great damage as the data under individual capabilities show to have been accomplished under conditions of heavy infestation [a] the total loss prevented by this expenditure would be equivalent to over $1,800. The profit may be considered, therefore, as about twelve times the investment.

Length of time required for hand-picking.—Bugs may be collected much more quickly on small or medium-sized plants than on large plants. In examining plants for the purpose of obtaining data on seasonal history the writer on one occasion examined and made a record of the number of bugs found on 1,892 plants in 2½ hours. Considering that the recording of the data occupied about the same length of time as would have been necessary to collect the insects, it would require about 6 hours at the rate given to collect the Pentatomids found in conspicuous positions on the plants in 1 acre. The native boys engaged in picking the bugs at Tlahualilo averaged about 30 minutes to each 300 plants, or about 7 hours per acre.

Practicability of hand-picking in the United States.—While the per diem cost of labor is much greater in the States of our cotton belt than in Mexico, where the experiments recorded were undertaken, this probably would be to a great extent (if not entirely) offset by greater efficiency. Especially good results should be obtained when hand-picking can be practiced under the direct supervision of the owner or some other person materially interested in the cotton. It

[a] Individual capabilities for damage have been shown to be greatest when infestation is lightest.

is believed that the data given in connection with the study of individual capabilities of the conchuela will be useful in the determination of the expense a cotton grower can afford to incur for hand-picking of the conchuela and other Pentatomid bugs when appearing in threatening numbers. It may be said summarily that the practicability depends on the available abundance of cheap labor and on the acreage of cotton that it is desired to treat.

OTHER METHODS OF COLLECTING BUGS FROM COTTON PLANTS.

In addition to collecting by hand, a test was made of the possibility of collecting the immature conchuelas by jarring them into a piece of canvas or cloth placed around the stalk of the infested cotton plants. Certain modifications of this method might be useful where the numbers of immature bugs on each plant is large, or where machines, such as have been devised but proven unsuccessful for the collection of the boll weevil and bollworm, might give good results in the collection of both nymphal and adult stages of the plant-bugs.

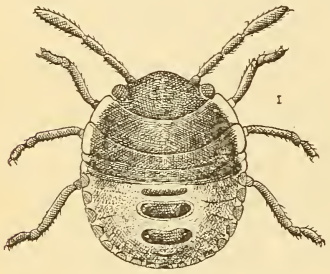

FIG. 10.—The grain bug (*Pentatoma sayi*): Nymph, first instar. Enlarged 21 diameters. (Original.)

CONTACT INSECTICIDES.

Adult Pentatomid bugs, in general, are known to be little affected even by strong solutions of contact insecticides. For ordinary field treatment insecticides, regardless of efficiency, are impractical for use against such insects as the conchuela. Their use might, however, be advisable under such conditions of excessive infestation as have been described as resulting from the migration of nymphs in 1905 at Tlahualilo. As suitable materials for making and applying kerosene mixture were not available, a test was made of cottonseed-oil soap solution, using one-half pound of soap in 4 gallons of water. This was found to destroy nymphs when thoroughly sprayed, but only 3 or 4 per cent of the adults succumbed to the same treatment.

TRAP CROPS AND ATTRACTION TO LIGHTS.

Early in the season, before bolls are put on by the cotton plants, a few mesquite bearing heavy crops of beans might serve a useful purpose by attracting the conchuelas. For good results it would be necessary that the development of the insects be carefully watched and treatment applied before the first of the spring nymphs reach maturity. Unless proper attention can be given, however, as has been indicated in the discussion of preventive measures, it is inad-

visable to allow mesquite to grow in the vicinity of cotton when it can be avoided. Observations thus far on the feeding habits of the conchuela have given us no reason to expect that a trap crop can ever be successfully used to divert the attention of the insect from the cotton after the bolls become suitable for food.

Under date of May 29, 1906, Mr. J. H. Vaughan, of Tlahualilo, Mexico, in a communication to the writer stated that the conchuela had already appeared on alfalfa. This directs attention to the advisability of giving close attention to this crop and of taking advantage of its attractiveness as a breeding place for the conchuela early in the season, to check its increase through means that have been suggested.

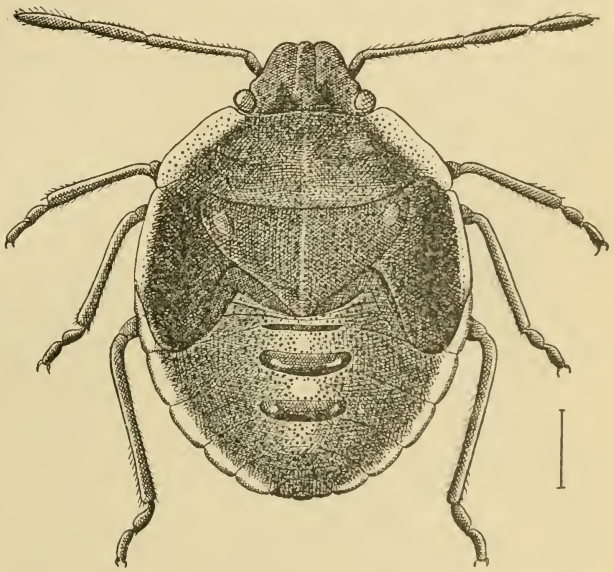

FIG. 11.—The grain bug: Nymph, fifth instar. Enlarged 6 diameters. (Original.)

The adult conchuela evidently never flies except during daylight. Many Pentatomids are commonly attracted to lights, but normally this species feeds almost continually at night, and in the laboratory either remains motionless, if not feeding, or, if feeding, continues uninterruptedly when an electric light is brought within a few feet of a cage in which specimens are confined.

THE GRAIN BUG.

(*Pentatoma sayi* Stål.)

At Tlahualilo, Durango, Mexico, the grain bug (figs. 10, 11) has been observed to be of frequent occurrence on cotton and to resemble the conchuela in its habits, life history, and seasonal history. At Barstow, Tex., where grain crops were accessible, no specimens were collected on cotton.[a] The preference of this species for the seed of grains and of alfalfa will probably be sufficient protection against its occurring in injurious abundance in cotton fields in this country.

[a] Bul. 64, Pt. I, Bur. Ent., U. S. Dept. Agr., p. 2, 1907.

Its distribution in the cotton belt is apparently restricted to western Texas, for there is no instance known to the writer of a specimen being taken east of the semiarid region of that State

PENTATOMID BUGS OF THE GENUS EUSCHISTUS.

The several species of Euschistus, the genus to which the brown cotton-bug belongs, have never attracted much attention from economic entomologists. Townend Glover [a] briefly described a Pentatomid which with little doubt belongs to this genus and noted that the species was abundant on cotton in Georgia in 1854 and in Florida in 1855, piercing the bolls and sucking their juices. The species referred to is probably *Euschistus punctipes* Say (*variolarius* Pal. Beauv.), as it is this one which the same author figured with the insects that attack young bolls in his "Manuscript Notes from my Journal." [b] The late Dr. Wm. H. Ashmead [c] recorded *E. pyrrhocerus* H. Schf. as not of rare occurrence in cotton fields in Mississippi and noted that it punctures new shoots and terminal branches.

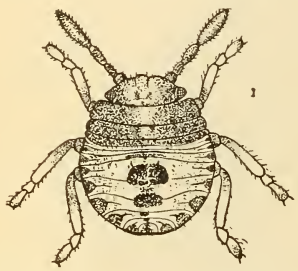

FIG. 12.—The brown cotton-bug (*Euschistus servus*): Nymph, first instar. Enlarged 21 diameters. (Original.)

So far as known to the writer these are the only published records of injury to cotton by species of Euschistus. Injury to tobacco by *E. variolarius* has been reported by Prof. H. Garman, [d] and by *E. fissilis* Uhl. to wheat by Prof. F. M. Webster. [e] Dr. J. A. Lintner [f] is responsible for the statement that the former species "feeds upon plants and animals interchangeably." Mr. A. H. Kirkland [g] has found *E. politus* to be partly predaceous.

In Texas *E. servus* Say is by far the most common representative of the genus found in the cotton fields and is the only one upon which special observations have been made in connection with the studies reported upon in this paper. The species was described in 1831 under the name *Pentatoma serva*. No observations have heretofore been recorded on the biology of the insect. *Euschistus impictiventris* Stål and *E. tristigmus* Say are the only other members of the genus which the writer has found upon cotton.

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[a] U. S. Agricultural Report for 1855, pp. 93–94.
[b] Plate 16.
[c] Insect Life, Vol. VII, p. 320, 1895.
[d] Bul. 66, Ky. Agr. Exp. Sta., pp. 33–34, 1897.
[e] Rep. Dept. Agr. for 1885, p. 317.
[f] 2d Rep. N. Y. St. Ent., p. 146, 1885.
[g] 44th Ann. Rep. Sec. Mass. St. Bd. Agr., 1896, pp. 406–407, 1897.

THE BROWN COTTON-BUG.

(*Euschistus servus* Say.)

DISTRIBUTION.

Dr. P. R. Uhler states[a] that *Euschistus servus* (Pl. I, fig. 2; text figs. 12, 13) inhabits Texas, New Mexico, California, "Dakota," Illinois, Maryland, and the Southern States generally. Mr. E. P. Van Duzee, who possesses the most extensive collection of the Pentatomidæ of America, states[b] that he has not seen types of this species from north of New Jersey and Ohio or west of Kansas, Texas, and eastern New Mexico. In Texas the species is of common occurrence throughout the eastern half of the State, being much more common in the northern portion of this section than in the southern portion. Toward the western and northwestern portions of the State the species gradually diminishes in numbers, possibly owing partly to decrease in cotton acreage. In Louisiana the brown cotton-bug is found throughout the State, though apparently, as in Texas, is more common in the central and northern than in the southern portion.

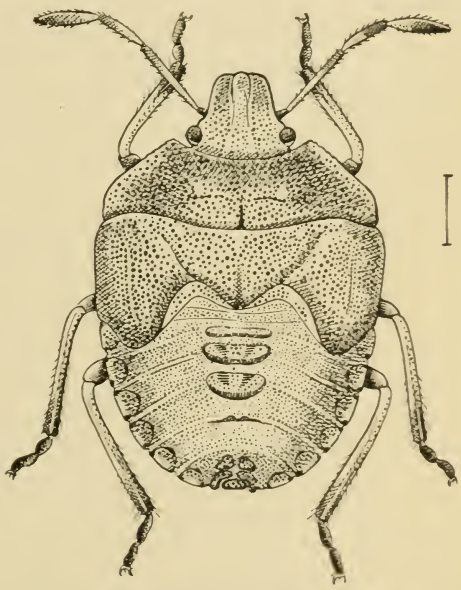

FIG. 13.—The brown cotton-bug: Nymph, fifth instar. Enlarged 6 diameters. (Original.)

FOOD PLANTS.

The brown cotton-bug has been taken on several other plants in addition to cotton, but specific records of actual feeding have not been made except in the case of specimens found feeding on the fruit of the orange in Florida,[c] and a specimen which the writer has observed feeding on green fruit and twigs of peach in confinement. The agents of the Bureau of Entomology who were connected with the cotton boll weevil investigations have collected this species in Texas and Louisiana on the following plants: Helianthus (three localities), corn (two localities), *Heterotheca subaxillaris* (two localities), *Rud-*

[a] Bul. U. S. Geol. and Geog. Surv., No. 5, second series; List of Hemiptera, p. 20, 1876.

[b] Trans. Amer. Ent. Soc.; XXX, p. 45, 1904.

[c] Insect Life, Vol. V, p. 264, 1893.

beckia sp. (one locality), *Rubus* sp. (one locality), peach (one locality), and evening primrose, *Gaura parvifolia* (one locality). In addition to these records, Scott and Fiske[a] have reported specimens of the brown cotton-bug abundant among material obtained incidental to extensive experiments in jarring for the plum curculio in Georgia.

LIFE HISTORY AND HABITS.

Four female and 1 male specimen and many nymphs of the brown cotton-bug were under observation in the laboratory. Egg-laying records of only 3 specimens are available, but these seem to show that the capacity of this species in this respect is fully equal to that of the species heretofore considered. The maximum number of eggs deposited by a single specimen was 162, the specimen concerned being collected on cotton on August 19, 1905. In confinement, a specimen collected in August lived 72 days, three specimens collected in September lived 90, 73, and 30 days, respectively, and a specimen collected in April lived 45 days. The last specimen probably had overwintered as an adult and was therefore several months old at the time the record began.

The average incubation period of 5 batches of eggs of the brown cotton-bug corresponded to within 8 hours with the average of 21 egg-batches of the conchuela. At an average daily mean temperature of 78.9° F., the average incubation period of 5 batches of eggs was found to be 4 days and 17 hours. The duration of the nymphal stages corresponds closely with that of the conchuela.

Observations thus far, in the regions where these studies were made, have not shown any decided preference of the brown cotton-bug for any particular food plant early in the season, but after the appearance of the bolls upon the cotton plants comparatively few specimens are found outside of the cotton fields. Doubtless weeds growing in profusion along the roadsides and fences furnish favorable breeding places in early summer for the bugs, which later turn their attention to the cotton.

On the average this bug deposits fewer eggs per batch than does the conchuela or grain bug. For 16 batches which have come under the writer's observation, the average number per batch was 16.4, the maximum being 34, and the minimum 5. Forty-two per cent were deposited in batches of 14 and its multiple.

The brown cotton-bug is occasionally attracted to lights, but not in sufficient numbers to lead to the belief that light trapping in badly infested cotton fields would give good results.

SEASONAL HISTORY.

In the latitude of Dallas, Tex., the hibernated individuals of both sexes of the brown cotton-bug are fairly common about or soon after

[a] Bul. 31, Div. Ent., U. S. Dept. Agr., p. 34, 1902.

April 1. A specimen confined on a peach tree deposited 2 egg-batches, containing in all 44 eggs, before the middle of May, 1906. Nymphs which hatched from one of these batches were in the second instar on May 13, but, as they disappeared soon after, definite information concerning the appearance of adults of the first generation was not obtained. From this and other records of eggs of this species collected in the spring of 1906, however, it can be safely considered to be between the 1st and the middle of June. A comparative study of the developmental periods of various Pentatomid bugs which have been under the writer's observation leads to the belief that it is probable that in the cotton-producing States a maximum of five generations per annum is possible, although four generations is doubtless a more common number, and three generations the most common of all. As with other Pentatomids whose egg-laying periods may extend over several weeks with each female, it is improper to speak of the generations as "broods," for the reason that individuals of from one to three different generations may and doubtless do occur together after the maturity of the first generation. The brown cotton-bug is most abundant in cotton fields during August and September, but no rapid increase or decrease in its numbers during the season has thus far been observed.

DESTRUCTIVENESS.

The usual association of the brown cotton-bug with other plant-bugs in the cotton fields has made advisable the general consideration of damage to cotton bolls resulting from the attacks of this and certain other species, which has been given in the introductory pages. The similarity of the feeding habits of the various Pentatomid bugs which attack cotton bolls indicates that the studies made concerning the individual destructive capabilities of the conchuela are fully applicable to the other species. Fortunately the brown cotton-bug has not as yet shown itself likely to appear over large territories in such abundance as has the conchuela. It has been observed in limited areas comprising only a few acres each, in numbers which caused destruction of the majority of the bolls, but thus far experience has shown this species to deserve the importance herein given, not on account of sporadic outbreaks in excessive numbers, but through its fairly constant and widespread occurrence throughout a large and important cotton-growing section.

NATURAL ENEMIES.

Species of Pentatomids of the genus Euschistus appear to be unmolested by Tachinid parasites. Examination of hundreds of specimens of species of this genus, including pinned material in collections and live specimens in the fields, has not thus far resulted in the finding of evidence of parasitism by these flies in any instance.

even when in the same fields parasitized specimens of other genera are numerous.

A Proctotrypid parasite, *Trissolcus euschisti* Ashm., has been recorded as having been reared from the eggs of *Euschistus servus* in Kansas. It has been stated in connection with the subject of egg parasites of the conchuela that the important agent in checking the multiplication of that species, *Telenomus ashmeadi* Morrill, in the laboratory does not hesitate to oviposit in the eggs of *Euschistus servus* and that adult parasites have duly emerged in such cases. This parasite is not at present known to occur in cotton-growing sections where the brown cotton-bug is found in abundance, but doubtless other Proctotrypids have more or less influence on the rate of multiplication of this bug.

PENTATOMID BUGS OF THE GENUS NEZARA.

THE GREEN SOLDIER-BUG.

(*Nezara hilaris* Say.)

HISTORY.

The frequent injuries by the green soldier-bug (Pl. I, fig. 3; text figs. 14, 15) to various crops and its wide distribution throughout the United States have resulted in its being one of the most generally known plant-bugs. A good general historical account of the species has been given by Sanderson in a previous bulletin of this Bureau.[a] The bug was first recognized as a cotton pest in 1855, Townend Glover [b] referring to its abundance on cotton in Florida and briefly describing the nature of its injury, evidently misidentifying it specifically. It was figured in 1878 by the same author[c] with insects injurious to cotton under the name *Nezara pennsylvanicus*. This error in identification has been indicated by Comstock.[d] A correspondent of the Division of Entomology[e] reported damage to cotton in Florida in 1890 by the green soldier-bug, and Sanderson (l. c.) briefly mentions damage to cotton in Texas from this insect in 1903 and 1904.

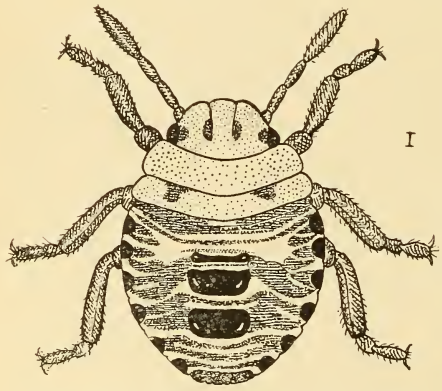

FIG. 14.—The green soldier-bug (*Nezara hilaris*): Nymph, first instar. Enlarged 21 diameters. (Original.)

[a] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 47–49, 1906.
[b] Agricultural Report for 1855, p. 93.
[c] Manuscript Notes from My Journal, etc., pl. 16.
[d] Report on Cotton Insects, 1879, p. 167.
[e] Insect Life, Vol. III, p. 403, 1891.

DISTRIBUTION.

Mr. E. P. Van Duzee [a] writes as follows in regard to the geographical distribution of the green soldier-bug:

This is a showy but very common insect throughout the northeastern United States and Canada. Toward the south its range extends through the Southern States and West Indies to Brazil. In the West it occurs in Kansas, Iowa, Colorado, Montana, Utah, Arizona, and Texas, and perhaps over all the Western States.

This is the most common Pentatomid found on cotton throughout our Southern States, although it is frequently exceeded in abundance locally by other species.

FOOD PLANTS.

The green soldier-bug, like the Pentatomid cotton pests which have been considered in the foregoing pages, is a very general feeder. A correspondent of the Division of Entomology in 1883 [b] reported the insect as occurring in abundance in Florida on tomatoes, egg-plant, turnip, mustard, peas, and oranges. Professor Sanderson [c] has compiled from the publications and correspondence files of the Bureau of Entomology the following additional list of food plants

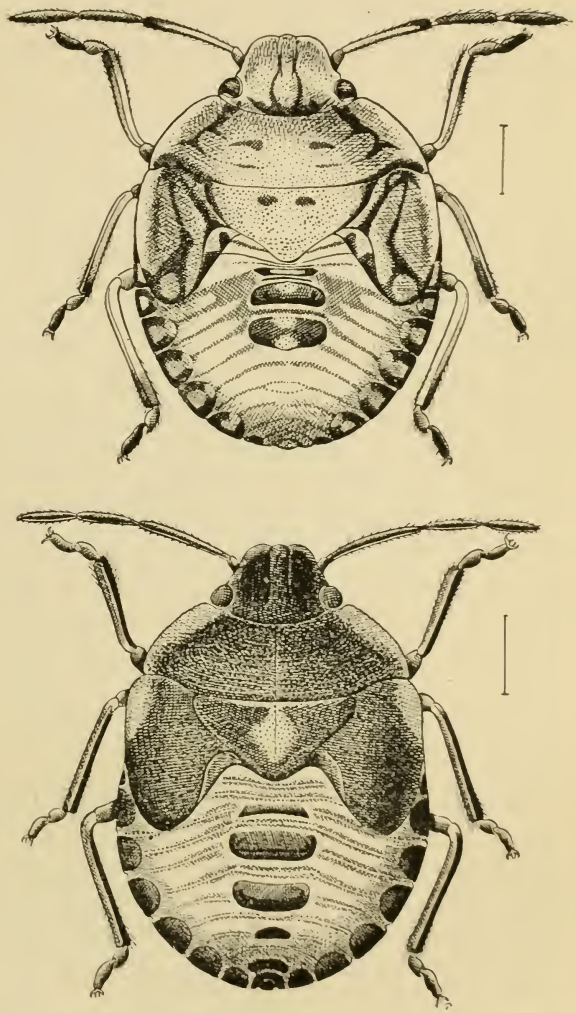

FIG. 15.—The green soldier-bug: Nymph, fifth instar; light and dark types. Enlarged 6 diameters. (Original.)

[a] Trans. Amer. Ent. Soc., Vol. XXX, p. 58, 1904.

[b] Insects affecting the orange. By H. G. Hubbard, 1885, p. 160.

[c] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 47–49, 1906.

which have been reported as injured by the green soldier-bug: Beans, cabbage, corn, cotton, peaches, and okra.

At Amherst, Mass., the writer has found nymphs of this species on maple trees and both nymphs and adults on European linden. The trees of the species last mentioned were fruiting and the bugs were breeding on them in unusually large numbers, feeding almost exclusively on the fruit. At Llano, Tex., he has found these insects feeding on the seed-pods of mesquite growing in close proximity to cotton fields.

LIFE HISTORY AND HABITS.

Specific records which are available indicate that eggs are deposited by the green soldier-bug in batches averaging a larger number of eggs than is the case with either the conchuela, the grain bug, or the brown cotton-bug. The eight batches which have come under the writer's observation averaged 40 eggs per batch, ranging from 27 to 52. A female specimen which died in the laboratory was found on dissection to contain 53 fully developed eggs.

The period of incubation of the eggs of this species has never been determined, but it is safe to assume that it is practically the same as that of the other Pentatomids investigated in the preparation of this report. Sanderson records the developmental period from the hatching of the eggs to the appearance of the adult in September and October, 1904, as 39 days, the observation being made in northern Texas, and the inclusive period from September 2 to October 11. Three adults, taken in a cotton field on October 19, 1905, lived in the laboratory until December 1, when they were used in a hibernation test under out-of-door temperatures. All three specimens were alive on December 19, but on March 8 two were dead, while the third had escaped from the cage in which the specimens had been confined.

The green soldier-bug, in cases heretofore recorded and in all cases which have come under the writer's observation, has shown a preference for the cotton bolls, as have other cotton-infesting Pentatomids. The insect does not, however, confine its attacks to the seed and fruit of its food plants, as reliable reports state that pea vines, orange twigs and leaves, and cabbage leaves have been attacked to the extent of causing serious damage. It has long been known that this species is sometimes predaceous, and owing to the lack of an adequate understanding of the nature of the injury to cotton due to plant-bugs, many have inferred that the good accomplished through the destruction of caterpillars outweighed the injury resulting from the bugs' feeding on the plant. This is far from representing the true status of the insect in the cotton field, for on the whole the predaceous habit is exceptional, and beyond occasionally diverting

the bug's attention from the cotton bolls is of practically no economic importance.

DESTRUCTIVENESS.

The green soldier-bug has shown itself to be of importance as a cotton pest not only owing to its widespread occurrence but also to the fluctuations in its numbers, which result in considerable local damage from time to time. An instance of this kind has been mentioned by Professor Sanderson.[a] The correspondent referred to, Mr. R. L. Taylor, of Help, Bosque County, Tex., has kindly furnished additional information concerning his experience with the insect. This is of sufficient interest to present in summarized form at this place, as it represents the experience of a cotton grower whose observations were made and conclusions arrived at independently of previous knowledge of the destructive capabilities of the insect. The accuracy of Mr. Taylor's observations is sustained by the close correspondence between his description of the effects of the green soldier-bug's attack and the effects of the attack of the conchuela, which has already been considered in detail. He writes that the insect was first noticeably abundant in 1901, and it was observed that year that many bolls failed to open perfectly; in some instances, from as many as 30 bolls on a plant not more than 5 opened and produced good lint. The insects were also abundant in 1902 and damage to bolls was again noticed. In 1903 the damage was not so severe, but much staining of lint was believed to be due to the work of the bugs. A local cotton buyer claimed that the condition of the lint was due to frost, although Mr. Taylor states positively that there had been no frost at the time (October). Whenever the bugs were present in numbers it was observed that the cotton was "spotted," that is, one, two, or three locks of a boll opened, while the remainder in each case failed to open. Shedding of badly damaged bolls was also noted in 1902, but this was probably confined mostly to bolls less than one-half grown, as was observed in the case of damage by the conchuela.

Bosque County, in which Help is situated, was first infested by the boll weevil in 1902, and the first damage to cotton in the county was observed in 1903. It should be noted that there is therefore no possibility of the confusion of injury by boll weevil attack with that of the green soldier-bug.

NATURAL ENEMIES.

No Tachinid parasites have thus far been reared from *Nezara hilaris*, and in only one instance has the writer found a specimen to

[a] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 47–48, 1906.

which an egg of one of these flies had been attached. This specimen was a female collected by Mr. F. C. Pratt, at Boerne, Tex., on beans, September 29, 1905. On October 12 the specimen died, but dissection showed no trace of the parasite.

The eggs of the green soldier-bug, however, are frequently parasitized. At Amherst, Mass., on July 15, 1902, large numbers of eggs were found on the leaves of European linden, and of about 250 collected more than 90 per cent produced Proctotrypid parasites.

From a batch of 27 eggs collected on September 29, 1905, by Mr. Pratt at Boerne, Tex., 15 parasites were reared. These proved to belong to the genus Trissolcus.

Professor Sanderson has referred to a report from a correspondent of the Bureau of Entomology, to the effect that a specimen of *Euthyrhynchus floridanus* L. had attacked and killed a specimen of the green soldier-bug, but this should probably be considered as, at the most, only an exceptional occurrence.

NEZARA VIRIDULA L.

The species *Nezara viridula* L. (fig. 16), which is readily distinguished from all other members of the genus by the shorter osteolar canal, has been found in many parts of the world. In the United States it occurs throughout the cotton belt. It has been reported as injurious to potato vines in India,[a] and in this country to sweet potato vines in Louisiana [b] and to oranges in Florida.[c]

Mr. W. A. Hooker, at that time an agent of this Bureau, who was located at Quincy, Fla., from October 23 to November 9, 1905, found this bug very abundant at that place, destroying potato vines and occurring commonly on cotton plants. The infested potato vines comprised a small patch of about one-fourth of an acre, and late in October it was estimated that there were on each vine an average of between 3 and 5 adults and 15 and 20 nymphs. The attacked vines turned dark, beginning at the tips of the branches—which seemed to be the favorite feeding place—and finally wilted. As the tubers had not attained their mature size the crop was much reduced. These bugs were in sufficient numbers on cotton plants in the vicinity to cause considerable damage, although the potato was evidently the more preferred plant.

Mr. Hooker took several specimens in Florida which had been attracted to light of ordinary kerosene lamps in houses and the writer has taken a specimen at a 16-candle power electric light at

[a] Insect Life, Vol. II, p. 61, 1889.
[b] Insect Life, Vol. V, p. 261, 1893.
[c] Insect Life, Vol. V, p. 264, 1893.

Victoria, Tex. In this connection it has been observed that in the laboratory at night adults of this species stop feeding, become restless, and fly about in the breeding cage when an electric lamp is turned on in the room.

On cotton the writer has taken a specimen of *Nezara viridula* on a boll at Cameron, La., and one at Johnsons Bayou, La., both on October 10, 1904, and has taken a fourth-instar nymph at Calvert, Tex., August 27, 1903, and a fifth-instar nymph at Victoria, Tex., November 10, 1904. Mr. F. C. Pratt found adults of the species common on turnip at New Braunfels, Tex., on October 27, 1905.

Of 39 specimens collected by Mr. Hooker at Quincy, Fla., in stages susceptible to parasitism by Tachinids, in only one instance was a Tachinid egg found attached to a bug. This bug was in the fifth nymphal instar and became adult 4 days after the egg was first observed and died 10 days later, but upon dissection no evidence of the presence of an internal parasite could be found.

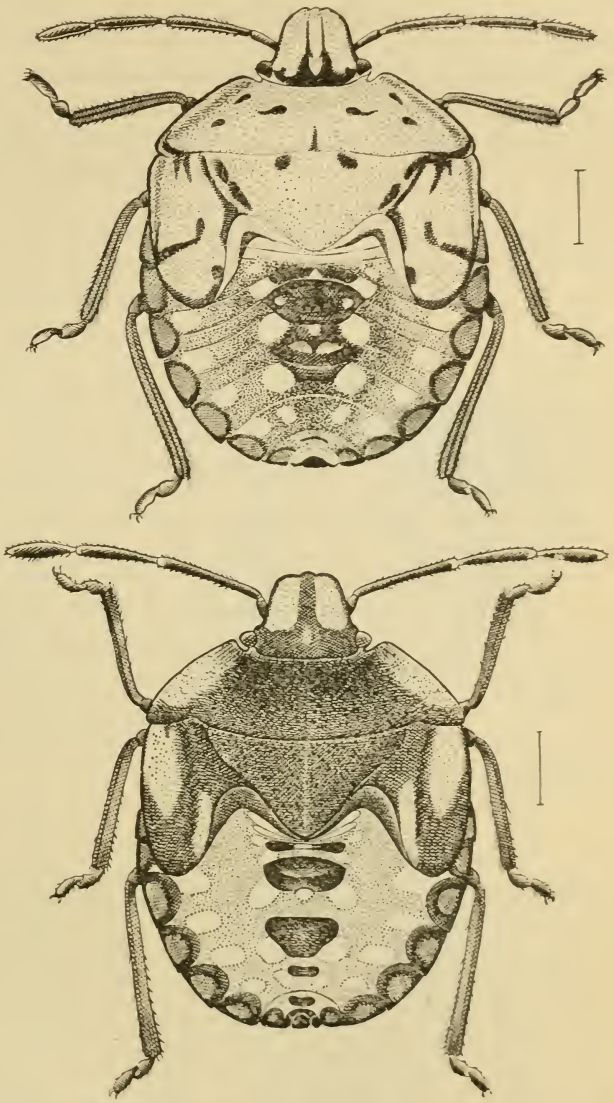

FIG. 16.—*Nezara viridula:* Nymph, fifth instar; light and dark types. Enlarged 6 diameters. (Original.)

PENTATOMID BUGS OF THE GENUS THYANTA.

(Plate I, fig. 4; text figs. 17 and 18.)

IDENTITY AND HISTORY OF SPECIES CONCERNED.

The writer has carefully examined a series of over 80 specimens which appear to represent a single species of the genus Thyanta and finds that the variation is so wide that while the majority are undoubtedly *T. custator* as described by Fabricius, several agree fairly well with the original description of *T. perditor* Fab. and *T. casta* Stål. Variations are found in size, form of humeral angles, proportionate lengths of the segments of the antennæ, and color and markings of the body, antennæ, and wing membranes, which might readily be mistaken for specific characters.

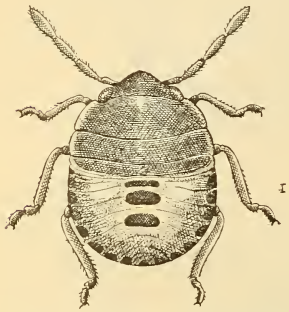

FIG. 17.— *Thyanta custator:* Nymph, first instar. Enlarged 27 diameters. (Original.)

These latter two species—if in fact they are valid—have not as yet been sufficiently characterized to distinguish them from the variations of the insect generally recognized as *Thyanta custator* Fab. Injury to crops by this species [a] was first recorded by Prof. E. D. Sanderson, who reported its occurrence in 1903 in unusual numbers in northern Texas, where it seriously injured oats, corn, and sorghum, and was also found in numbers on milo maize and cowpeas. The frequent occurrence of this insect on cotton bolls has also been noted by Sanderson.

DISTRIBUTION.

Uhler states in regard to the distribution of *Thyanta custator* that the species inhabits upper and lower California, Texas, Arizona, Colorado, "Dakota," and the Atlantic region generally from Quebec to Florida.[b] According to Mr. Van Duzee, it occurs in greatest abundance toward the South and West.[c] In Texas it is one of the most common Pentatomid bugs and is especially abundant in the northwestern part of the State. Except in northern Texas and Oklahoma, it seems to be of too rare occurrence on cotton to be worthy of consideration as a pest.

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[a] At first determined as *Thyanta perditor* Fab. and afterwards redetermined as *T. custator* Fab. Compare Bul. 46, Div. Ent., U. S. Dept. Agr., p. 94, 1904, with Bul. 57, Bur. Ent., U. S. Dept. Agr., p. 49, 1906.

[b] Bul. U. S. Geol. and Geog. Surv., No. 5, Second series, List of Hemiptera, p. 23, 1876.

[c] Trans. Amer. Ent. Soc., XXX, p. 53, 1904.

FOOD PLANTS.

Sanderson[a] has noted injury by this species to oats, corn, and sorghum, and its occurrence upon milo maize, cowpeas, and cotton. It has been observed by the writer feeding in considerable numbers on mesquite beans and records of the specimens in the collection of the Bureau of Entomology indicate the wide range of plants upon which the insect has been collected.

LIFE HISTORY AND HABITS.

Observations on life history were made upon 6 female specimens. Three specimens captured at Dallas, Tex., in early September produced a total of 377 eggs in 130 days, the average per specimen being 4 more than that of 14 females of the conchuela collected on September 12. The maximum longevity of the specimens under observation was 39 days except for one specimen, which matured on October 8, and hibernated, being alive on December 19.

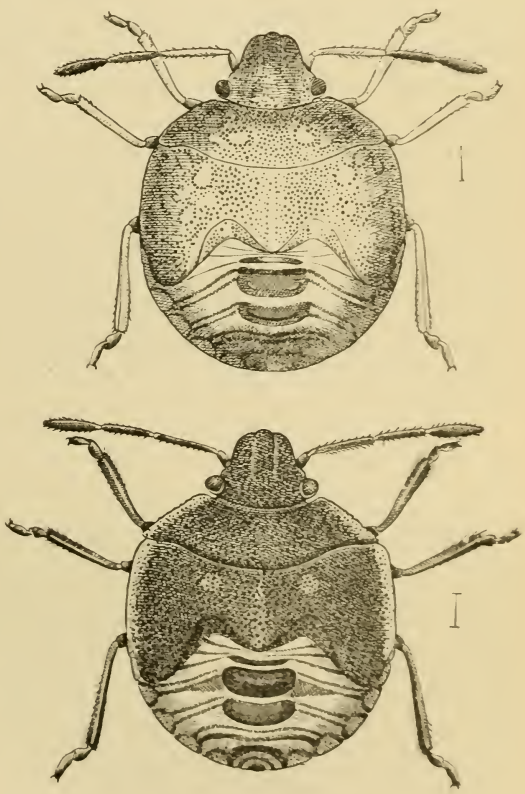

FIG. 18.—*Thyanta custator:* Nymph, fifth instar; light and dark types. Enlarged 10 diameters. (Original.)

The incubation period of the eggs of this species agrees closely with the species discussed in the preceding pages. At an average daily mean temperature of 79.3° F., the average incubation period of 4 batches was 4 days and 15 hours. The duration of the nymphal stages seems to be considerably more brief for *Thyanta custator* than for the conchuela and other Pentatomids heretofore discussed. The writer's records show that the nymphs of *Thyanta custator* develop as rapidly at an average daily mean temperature of 64.7° F. as do the nymphs of the conchuela at an average daily mean temperature of 82° F.

[a] Bul. 46, Div. Ent., U. S. Dept. Agr., p. 94, 1904.

Records based upon 14 batches of eggs deposited in the laboratory indicate that the average number of eggs deposited per batch is high as compared with most Pentatomids. These records gave an average of 31.4 eggs per batch, the range in number being from 10 to 42.

In its selection of food plants *Thyanta custator* has thus far exhibited a preference for grains and cotton, although this may be only the natural consequence of the fact that these are the principal crops grown in the section of the cotton belt where this Pentatomid is most abundant. At Tlahualilo, Durango, Mexico, where this bug was common in July, 1905, it was not found on alfalfa as were several other cotton-infesting plant-bugs, nor has it thus far been reported as occurring in alfalfa fields in Texas. A specimen of *Thyanta custator* in the fifth nymphal instar, immediately after being brought into the laboratory from the cotton field, fed upon eggs of the conchuela, exhibiting the only instance of a predatory habit which has been observed in this species.

In the cotton fields this bug is commonly found feeding on the cotton squares and bolls—when feeding being frequently completely hidden by the bracts. This habit of concealment, together with its small size and inconspicuous color, makes it much more difficult of detection when present on cotton plants than are the other cotton-infesting Pentatomids which have been dealt with in the foregoing pages. The preference of the bug for the bolls over other portions of the cotton plant is fully as well marked as it is in the case of the conchuela.

Gregariousness is also as well marked a characteristic of this species as of the conchuela.

In October, 1897, Mr. J. D. Mitchell, in testing, at Victoria, Tex., the possibility of trapping the cotton boll weevil by lights, captured 4 specimens of *Thyanta custator* in a one-night trial of 3 lights.[a] A specimen was taken at a light by Mr. J. C. Crawford at San Antonio, Tex., in May, 1905, and one by Messrs. Crawford and Pratt at Cotulla, Tex., on May 12, 1906. It is possible that trap lights might be successfully used against this insect in badly-infested fields of grain or cotton, for in the localities above mentioned where specimens have been captured by this means the species is comparatively scarce and the chances of capture proportionally reduced.

SEASONAL HISTORY.

The writer has found *Thyanta custator* in cotton fields in greatest abundance in September and October. In view of its occurrence in more or less destructive numbers in grain fields in northern and northwestern Texas it seems likely that the time of its appearance in greatest numbers in cotton fields may be dependent upon the harvesting

[a] Bul. 18, Div. Ent., U. S. Dept. Agr., p. 88, 1898.

of grain crops. During the first week in November, 1904, these bugs were found in large numbers inside the bracts of cotton bolls in various localities in northwestern Texas, commonly known as the "Panhandle." Feeding was not observed in any case, the bugs appearing in a hibernating condition in the most protected location the cotton plants afforded, quiet and exhibiting signs of life only when disturbed. In 1905 this species was rarely found in the cotton fields in the vicinity of Dallas, Tex., during August, but on September 9 it was noted as much more numerous than the brown cotton-bug (*Euschistus servus*), which occurred in fairly large numbers in August, and had shown no diminution in numbers.

A nymph of *Thyanta custator* in the fifth instar was collected by Mr. F. C. Pratt, at Kerrville, Tex., on May 30, 1906, this being the earliest spring record of the collection of a specimen in this stage, as far as known to the writer.

NATURAL ENEMIES.

Eggs of Tachinid flies are frequently found attached to adults of *Thyanta custator*, but as none of these parasites has as yet been reared to maturity, they are unknown specifically. On examination of 113 specimens of this Pentatomid in the collection at the laboratory of the Bureau of Entomology, at Dallas, Tex., 14, or about 12 per cent, were found to be parasitized.

In the laboratory *Telenomus ashmeadi* Morrill has been reared from the eggs of this species and egg-batches have been collected in the fields from which parasites had emerged.

OTHER PENTATOMIDS FREQUENTING OR ATTACKING COTTON.

In addition to the species mentioned in the foregoing pages the following Pentatomids are not infrequently found on cotton plants: *Murgantia histrionica* Hahn, *Podisus maculiventris* Say, *Podisus acutissimus* Stål, *Proxys punctulatus* Pal. Beauv. and *Stiretrus anchorago* Fab. With the exception of the first named—the harlequin cabbage-bug—these species are normally predaceous, but it is probable that all predaceous Pentatomids will feed more or less on plant juices when the supply of caterpillars or other insect food is insufficient. Of the five species mentioned, the harlequin cabbage-bug alone feeds exclusively on plants. This bug is never found widely distributed in cotton fields and is rarely met with in sufficient abundance to cause noticeable damage. Mr. W. A. Hooker found this bug in unusual abundance on cotton at Farmersville, Tex., on September 2, 1904, and discovered the source of infestation to consist of a small cabbage-patch located about 10 rods distant. Somewhat similar conditions have been noted in other instances.

INSECTS OF THE SQUASH-BUG FAMILY (COREIDÆ) INJURIOUS TO COTTON.

THE LEAF-FOOTED PLANT-BUGS.

(*Leptoglossus phyllopus* L., *L. oppositus* Say, and *L. zonatus* Dall.)

A review of the economic status of the northern leaf-footed plant-bug (*Leptoglossus oppositus* Say) and the banded leaf-footed plant-bug (*Leptoglossus phyllopus* L.) was presented by Dr. F. H. Chittenden in an early bulletin of this series.[a] In a later bulletin a more extended account of the former species, including description of all the immature stages and observations on the life history and habits, was given by the same author.[b] Both of these species are commonly found in greater or less abundance in cotton fields throughout the various cotton-growing States. *L. zonatus* Dall. is of comparatively rare occurrence in the United States, and probably for this reason no record of its attacking cotton in this country is available, although the author has noted its injury to cotton bolls in Mexico, where it is more abundant.[c]

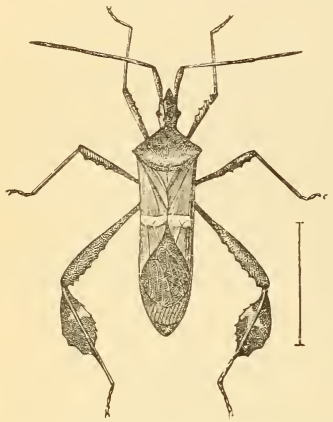

FIG. 19.—The leaf-footed plant-bug (*Leptoglossus phyllopus*): Adult. Twice natural size. (After Hubbard.)

LEPTOGLOSSUS PHYLLOPUS L.

Leptoglossus phyllopus (Pl. I, fig. 6; text fig. 19) is the most common species of the leaf-footed plant-bugs found in cotton fields. Doctor Chittenden has recorded its principal cultivated food plants, showing it to be an almost omnivorous plant feeder and one likely to cause serious local damage to many crops, both fruit and vegetable. Ashmead, in recording his observations made in July, 1893,[d] mentioned the insect as of common occurrence in cotton fields in Mississippi, sometimes as many as 3 or 4 together being observed on a single boll.

About 20 adults of this species were observed by the writer on a single cotton plant near Mason, Tex., on October 20, 1905. They began to take wing when the writer was quietly watching from a distance of several feet and in less than a minute only 2 or 3 specimens remained. On the whole, however, these bugs were not very numerous in the locality named, not exceeding, on the average,

[a] Bul. 19, n. s., Div. Ent., U. S. Dept. Agr., pp. 44–48, 1899.
[b] Bul. 33, n. s., Div. Ent., U. S. Dept. Agr., pp. 18–25, 1902.
[c] Bul. 54, Bur. Ent., U. S. Dept. Agr., p. 33, 1905.
[d] Insect Life, Vol. VII, p. 320, 1895.

1 specimen to every 10 plants. Prof. Wilmon Newell, secretary of the State Crop Pest Commission of Louisiana, and his assistants, while inspecting cotton fields for the Mexican cotton boll weevil in Rapides Parish, La., in September, 1905, found this species of leaf-footed plant-bug very abundant. The following quotation from Professor Newell's notes, which he has kindly permitted to be used in this bulletin, illustrates the degree of importance these insects may attain in consideration of the individual destructiveness of plant-bugs, as shown in the studies of the conchuela.

On September 7, in western Rapides Parish, adults of this species were found in abundance in cotton fields, usually resting or feeding on green bolls. In two or three fields near Forest Hill, these insects were so abundant as to average at least 2 adults to each stalk of cotton. Their damage in the aggregate must be considerable. Hemipterous nymphs found on the bolls appeared to be of this species. Between September 1 and 10 these bugs were found in greater or less abundance in every cotton field inspected in Rapides Parish.

The author considers the species of plant-bug here discussed fully the equal of the conchuela in individual destructive capabilities. The data given in Table XXVI (p. 57) show that in one cotton field damage by the conchuela amounted to about 50 per cent when the bugs were about one-fourth as numerous as were the leaf-footed bugs in the 3 fields near Forest Hill, La., referred to by Professor Newell.

On September 9, 1905, a female was taken in coitu and brought to the laboratory. It was supplied with fresh cotton bolls daily, but produced no eggs and died on October 28, the forty-ninth day of its confinement in the breeding cage. Upon dissection only 1 egg was found; this was of mature size and color, closely resembling in size, structure, and color the eggs of *L. oppositus*, described and figured by Dr. Chittenden. H. G. Hubbard[a] has stated that the normal food plant of this bug in the South is a large thistle. Mr. F. C. Pratt observed adults in considerable numbers on dockweed (*Rumex* sp.) near San Antonio, Tex., on April 19, 1906, feeding and copulating, and on thistles near Baton Rouge, La., on April 22, 1906.

Professor Newell found on May 19, 1905, in Sabine Parish, La., adults of *L. phyllopus* in abundance upon stems and seed-pods of "bear grass" (*Yucca filamentosa*), a common weed in the western part of that State and generally found in greater or less abundance in and around all cotton fields. In many cases the adults occurred upon the "bear grass" so abundantly that the stems and seed-pods were literally covered with them, and in several cases two or three dozen specimens were collected from the stems and seed-pods of a single plant. The insects could not be found on any other plant and seemed to depend entirely upon the "bear grass" for their subsistence at that season of the year.

[a] Insects affecting the Orange, p. 169, U. S. Dept. Agr., Div. Ent., 1885.

Leptoglossus oppositus Say.

Leptoglossus oppositus (figs. 20, 21) is of somewhat less common occurrence in cotton fields than *L. phyllopus*, but east of the Mississippi River and north of Florida it apparently exceeds that species in general abundance. It has been referred to by Dr. Chittenden as the "northern leaf-footed plant-bug."

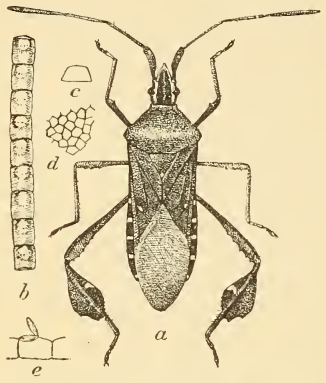

FIG. 20.—The northern leaf-footed plant-bug (*Leptoglossus oppositus*): *a*, Mature bug; *b*, string of eggs; *c*, egg from end; *d*, sculpture of egg; *e*, egg from side, showing opening from which young has escaped. *a*, *b*, *c*, *e*, Natural size; *d*, about twice natural size. From Chittenden.

On September 21, 1905, in Menard County, Tex., the writer found, on two bolls which were situated close together on a cotton plant, between 25 and 30 specimens of this species in the third nymphal instar. Twenty specimens were collected and brought to the laboratory at Dallas. These molted between September 21 and 23. On September 29, 2 molted again although 3 specimens were still in the fourth stage on October 3. One of those which molted on September 29 became adult on October 21; all others died before reaching maturity.

Prof. H. Garman, entomologist of the Kentucky Agricultural Experiment Station, records the finding of nymphs supposed to be

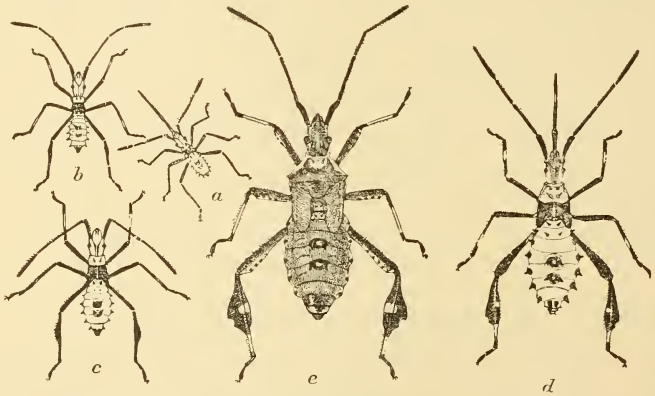

FIG. 21.—The northern leaf-footed plant-bug: *a*, Nymph of first instar; *b*, second instar; *c*, third instar; *d*, fourth instar; *e*, fifth instar. Enlarged about 3 diameters. From Chittenden.

this species in large numbers on Spanish bayonet or "bear grass" (*Yucca filamentosa*) at Lexington, Ky., July 7, 1899. With this exception information concerning wild food plants of this species is wanting but with little doubt various weeds, including thistles and "bear grass," will be found to be included in the list.

Leptoglossus zonatus Dall.

Leptoglossus zonatus was observed by the writer to be fairly numerous in cotton fields at Tlahualilo, Durango, Mexico, in September, 1904, but in the same locality, in July, 1905, not a specimen was found although cotton fields were visited daily during the month. It is not likely that this bug will ever become common in cotton fields in this country except possibly in certain districts in the semiarid region of western Texas.

OTHER COREIDS KNOWN TO ATTACK COTTON.

In the Agricultural Report for 1855, Glover mentioned *Acanthocephala femorata*[a] (Pl. I, fig. 5) as an insect frequently found in cotton fields in Florida. Professor Comstock[b] in his Report on Cotton Insects, 1879, quotes from a statement by Mr. W. Trelease, to the effect that these bugs were several times observed to catch and suck the juices from the bodies of cotton caterpillars, *Alabama* (*Aletia*) *argillacea* Hbn. It was consequently concluded that at that time the knowledge concerning the habits of the bug favored its being considered a friend of the cotton grower. Ashmead[c] stated in regard to this species as observed by him in Mississippi in 1893 that it was "captured several times puncturing young bolls and while not especially numerous does considerable damage."

The flat-horned Coreid (*Chariesterus antennator* Fab.) is recorded by Ashmead as common in cotton fields in Mississippi. Prof. E. D. Sanderson[d] has given brief notes on two species, *Corizus pictipes* Stål and *Jadera hæmatoloma* H.Schf., which are frequently found on cotton, although by themselves not in sufficient numbers to do appreciable damage. In addition to the above-mentioned species of Coreids the writer has occasionally found on cotton a strikingly marked bug, *Hypselonotus fulvus* De G., which may appropriately be known as the banded-legged Coreid. This insect occurs commonly in southwestern Texas, but is not usually found on cultivated plants.

NATURAL ENEMIES OF COREIDS DESTRUCTIVE TO COTTON.

Mr. R. C. Howell, formerly a field agent of this Bureau, collected, on August 15 at Sulphur Springs, Tex., a batch of 42 eggs of a species of Leptoglossus, which had been deposited on the bract of a cotton square. From these eggs 3 Proctotrypid parasites emerged, which Doctor Ashmead determined as *Hadronotus anasæ* Ashm. This parasite was first reared from the eggs of the squash-bug

[a] Referred to as *Anisoscelis* ?, p. 95, Pl. VIII, fig. 9.

[b] Report on Cotton Insects, p. 168, U. S. Dept. Agr., 1879.

[c] Insect Life, Vol. VII, p. 320, 1895.

[d] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 46–47, 1906.

(*Anasa tristis* DeG.) by Doctor Ashmead in 1886. During the summer of that year it was found in Florida that about 30 per cent of the eggs of *Anasa tristis* were parasitized by this insect. A closely related Proctotrypid has been reared by Ashmead from the eggs of *Acanthocephala* (*Metapodius*) *femorata* Fab.

A Tachinid fly, *Trichopoda pennipes* (fig. 22), has been reared from *Leptoglossus oppositus*. Doctor Chittenden[a] states that eggs of this fly were frequently noted, attached to the thorax of adults of this bug, in the vicinity of Washington, D. C., in 1901. The fly has previously been reared from adults of the squash-bug. It occurs in Texas, Mississippi, Florida, and in probably all of the cotton-growing States. It seems to be of little consequence as a natural check to the leaf-footed plant-bugs in Texas, for among 58 specimens of *L. phyllopus* and 24 specimens of *L. oppositus* in the collection of the Bureau of Entomology at the laboratory at Dallas, Tex., only a single specimen of the latter species bore a Tachinid egg. This was attached to the upper surface of the head of an adult male specimen collected by Mr. F. C. Bishopp at Paris, Tex., on August 26, 1905.

FIG. 22.—*Trichopoda pennipes*, a Tachinid parasite of Coreid plant-bugs: Adult. Enlarged about 3 diameters. (From Chittenden.)

INSECTS OF THE LEAF-BUG FAMILY (CAPSIDÆ) INJURIOUS TO COTTON.

Thus far the only species of the family Capsidæ which has proved itself of importance as a cotton pest is the cotton leaf-bug (*Calocoris rapidus* Say, fig. 23). This species was first mentioned in this connection by Townend Glover[b] in 1856. It is widely distributed in North America and is found in all the cotton-growing States. Practically all that is known concerning the life history and habits of this insect is presented by Sanderson[c] in a report of observations made in 1904. Investigations thus far have not revealed any practical method of combating the adult bugs, although destruction of nymphs by a spray of kerosene emulsion may be advisable under some circumstances. The practicability of attracting the adults to light has not been thoroughly tested. Hon. J. D. Mitchell, of Victoria, Tex., captured 165 specimens by the use of 3 trap lanterns in a cotton

[a] Bul. 33, Div. Ent., U. S. Dept. Agr., p. 25, 1902.
[b] Agricultural Report for 1855, p. 87, Pl. VII, fig. 6, 1856.
[c] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 44–46, 1906.

field near Victoria, Tex., on the night of October 1, 1897,[a] while Professor Sanderson reports 6 as the maximum number of the bugs collected at a single trap lantern at Terrell, Tex., in July, 1906.

Under date of July 7 and August 10, 1898, the Bureau of Entomology received from Mr. J. D. Mitchell specimens of a Capsid known to science by the name of *Psallus delicatus* Uhl., which was reported to occur on cotton in large numbers at Victoria, Tex., and to be very destructive to the young bolls.

INSECTS OF THE CHINCH BUG FAMILY (LYGÆIDÆ) INJURIOUS TO COTTON.

The false chinch bug (*Nysius angustatus* Uhl.) has been reported injurious to cotton in Texas and Louisiana by Professor Sanderson,[b] and in Mississippi by Prof. G. W. Herrick.[c] The attack of these insects is for the most part directed toward the young plants before

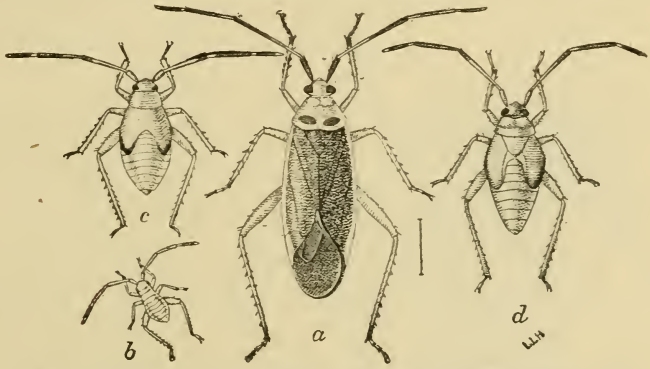

FIG. 23.—The cotton leaf-bug (*Calocoris rapidus*): *a*, Adult; *b*, young nymph; *c*, fourth instar of nymph; *d*, fifth instar of nymph. Much enlarged. (From Sanderson.)

the appearance of the fruit, and the insects should not properly be included in dealing with plant-bugs injurious to cotton bolls.

Two large Lygæids, *Oncopeltus fasciatus* Dall. and *Lygæus turcicus* Fab., were common on cotton at Tlahualilo, Durango, Mexico, in July, 1905, and young of both species were found feeding on alfalfa. They have been observed to attack both cotton squares and bolls. In the collection of cotton insects taken in Texas and surrounding States by the agents of the Bureau of Entomology connected with the cotton boll weevil investigations, only the second species is represented, although both are of common occurrence in Texas. Milkweeds (*Asclepias* spp.) seem to be the natural food plants of both these species. To illustrate the general appearance of bugs of this family a specimen of *Oncopeltus fasciatus* is shown by Plate I, figure 9.

[a] Bul. 18, Div. Ent., U. S. Dept. Agr., p. 88.
[b] Bul. 57, Bur. Ent., U. S. Dept. Agr., pp. 29–31, 1906.
[c] 17th Ann. Rep. Miss. Exp. Sta., p. 31, 1904.

INSECTS OF THE COTTON STAINER FAMILY (PYRRHOCORIDÆ) INJURIOUS TO COTTON.

THE BORDERED PLANT-BUG.

(*Largus succinctus* L.)

This insect (Pl. I, fig. 7; text figs. 24, 25) has been briefly mentioned as a minor cotton pest by Professor Sanderson,[a] who has indicated the more important published references. The insect is generally distributed throughout the Southern States. Lintner has recorded its attack on ripening peaches at San Antonio, Tex., in 1885, but this apparently indicated nothing more than an occasional depredation. The insect has been observed by the present writer to breed in enormous numbers in alfalfa fields at Tlahualilo, Durango, Mexico. It has also been found in certain regions in Texas breeding on a weed, *Solanum torreyi*, and on mesquite, but in each case only when growing in the vicinity of cotton fields. Eggs are deposited in trash in masses averaging, in four instances, 180 eggs each, and ranging from 108 to 215.[b] The eggs hatch in about ten days at an average daily mean temperature of 74° F. while about twice that time is necessary when the temperature is 10 degrees lower. The damage to cotton bolls by the bordered plant-bug is the same as that caused by the Pentatomid and Coreid bugs heretofore discussed. Their preference for the cotton boll is not as strongly marked, however, adults and nymphs being much more frequently found feeding on the outside of cotton squares at the base of the bracts. The writer knows of no instance of this bug occurring in cotton fields in numbers sufficient to cause by itself noticeable damage except as observed in a few fields in Mason and Llano counties, Texas, in 1905. In all cases referred to, the mesquite and the solanaceous weed mentioned above were evidently the chief breeding places and as a rule only near-by cotton plants were damaged. The newly-hatched nymphs have a dark brownish head and thorax, and reddish abdomen. Later nymphal stages are characterized by a greenish or bluish-black color with red markings.

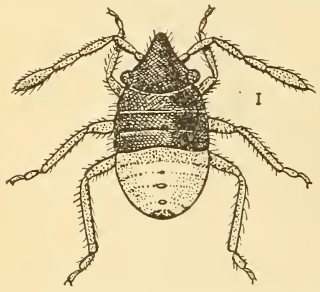

FIG. 24.—The bordered plant-bug (*Largus succinctus*): Nymph, first instar. Enlarged 21 diameters. (Original.)

[a] Bul. 57, Bur. Ent., U. S. Dept. Agr., p. 46, 1906.

[b] Professor Sanderson's record of 215 eggs in a mass is the maximum number referred to above.

THE COTTON STAINER.

(*Dysdercus suturellus* H. Schf.)

The cotton stainer (Pl. I, fig. 8), or "red bug," as it is sometimes called, is a native of tropical America and although long known as a cotton pest it is of limited distribution in this country, where thus far damage to cotton has been reported only from Florida.

Riley and Howard [a] have given the most complete account of this insect that has been published. The differences in opinion among various observers as expressed in published writings concerning the nature of the injury by this insect to cotton have been discussed by the writer under the general subject of injury by plant-bugs.

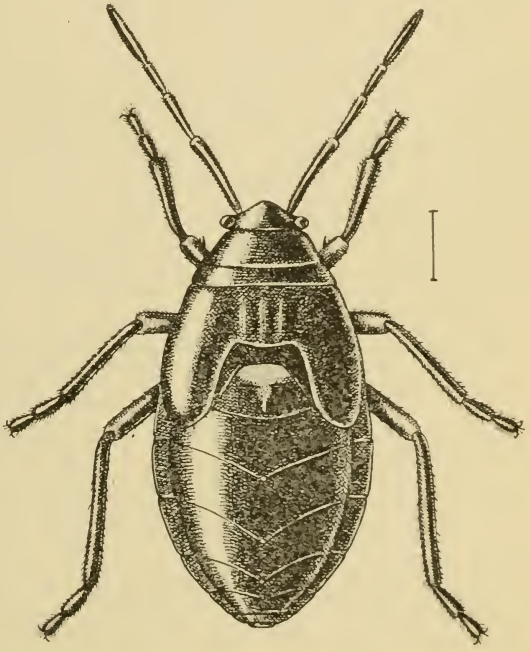

FIG. 25.—The bordered plant-bug: Nymph, fifth instar. Enlarged 6 diameters. (Original.)

Riley and Howard have referred to the records of food plants and supposed food plants. Aside from the cotton and orange, the cotton stainer has been observed to feed on certain undetermined malvaceous plants and has been found on certain species of Hibiscus, on the leaves of guava (Psidium), on Spanish cocklebur (*Urena lobata*), and night-shade (*Solanum nigrum*). The writer has observed these insects breeding in large numbers at Orlando, Fla., on Spanish cocklebur growing in and near orange groves, but has never observed them to feed on citrus fruits, except in cases where they were in confinement. Undoubtedly, as Riley and Howard have indicated, the habit of feeding on oranges is a temporary one and is probably due to the destruction of more natural food plants by frost or other causes.

Mr. H. A. Ballou has given some records of egg-laying of certain West Indian species of cotton stainers, but the writer knows of no published records of this kind concerning the American form here discussed. On October 8, 1906, 4 females and 4 males collected on

[a] Insect Life, Vol. 1, pp. 234–241, 1889.

cotton at Hawthorn, Fla., were confined in a cage at the writer's laboratory at Orlando, Fla. Within 24 hours after capture, 334 eggs were deposited and each of the 4 females was observed to be much less robust, presumably, therefore, having deposited eggs. These specimens all died between October 18 and October 25, 1906, during the writer's absence from the laboratory. In all, 465 eggs were deposited by the 4 females, an average of 116 eggs each. These were deposited both loosely in the sand at the bottom of the cage and in masses containing up to about 100 each. The eggs do not form compact masses, nor do they adhere to any object when freshly deposited. When covered by as much as one-fourth of an inch of loose sand the nymphs were unable to free themselves from the eggshells and died in all cases as far as observed. On October 26 an adult female was taken in coitu on cocklebur at Orlando, Fla., being selected from a large number on account of its abdomen being the most dilated, presumably with eggs. Upon dissection 78 full-sized eggs were found. It is possible that a few, not exceeding 6 eggs, were destroyed in dissecting. It seems probable that about 80 or 85 eggs is the largest number which one female may deposit at one laying, and this observation furnishes additional evidence that each of the 4 females heretofore referred to deposited eggs on more than one occasion.

Gregariousness is a very strongly marked habit in this insect and is of great importance in its control in the cotton fields.

The writer's observation in a cotton field at Hawthorn, Fla., in October, 1906, showed that the cotton stainer's injury to immature bolls (Pl. III, figs. 2–7) exhibits the same characteristics as that by the Pentatomids and other plant-bugs which have been treated of herein. This injury, often resulting in complete destruction of the entire boll affected, or of one or more of its locks, is generally considered by cotton growers in Florida to be due to climatic conditions. It seems, however, to be more frequently ascribed to too much rain, whereas, as has been stated, in Texas the plant-bug injury of this kind is more often ascribed to dry weather. In one field the writer has estimated that not less than 15 per cent of all bolls were destroyed by the feeding of cotton stainers during the growing season. It is important that the source of this ordinary plant-bug injury be recognized. Brief observations at Hawthorn in 1906 cleared up much of the uncertainty in regard to the nature of the yellowish stain of the lint which is the generally recognized result of attack by the cotton stainer. Mr. Johnson, of the firm of Smith & Johnson, cotton ginners at Hawthorn, is well informed concerning this insect and its work. It is his observation that the staining of the lint is due to the bug's attack on the immature bolls and on the seed at the time of opening, the brownish-yellow color being derived from the injured

seed rather than from the excrement of the bugs. The writer's observations support this view in regard to the source of the stain, for an examination of a considerable amount of seed cotton which had been badly stained by the bugs showed almost invariably that the stain was most intense immediately surrounding the seed. (Pl. II, fig. 3.) Sometimes it is only the fibers at one end of the seed that are affected, but more often all of the fibers attached to a damaged seed are more or less brownish at their bases while at the outer ends they rarely show traces of stain. It is inconceivable that the excrement of the cotton stainers should stain the fiber in such a manner. Moreover, according to the writer's observations the amount of excrement is too small to result in any appreciable damage. On one occasion as many as a dozen adult cotton stainers have been observed on a single plant feeding on the seed of the open bolls with no trace of stain that would be expected if the insects voided their yellowish liquid excrement with sufficient frequency to damage the lint. In the laboratory 8 specimens, including 4 males and 4 females, were confined in a cage, the bottom of which was covered about an inch deep with seed-cotton having pure white fiber. In 10 days, during which the bugs fed on a green cotton boll and a piece of orange rind, the cotton seed and the lint were unstained, although in one or two instances excrement had been voided on the sides of the cage. While there is undoubtedly some staining of the cotton fiber, due to the excrement of the bugs from the evidence at hand, the writer concludes that damage from this source is inappreciable.

At present the cotton stainer is the most destructive cotton pest in Florida and presumably does occasional damage to cotton in Georgia and neighboring portions of South Carolina and Alabama, where its occurrence has been recorded by Dr. L. O. Howard.[a] Its outbreaks are sporadic, however, and rarely occur over large areas. Dr. E. H. Sellards, formerly entomologist at the Florida Agricultural Experiment Station, reports that the cotton stainer was abundant in 1904, and in one instance it was claimed that the complete destruction of 25 acres of long-staple cotton was due to this insect.[b] In 1902, Smith & Johnson, of Hawthorn, ginned about 1,000 bales of long-staple cotton, of which about 200 bales were classed as stained. Fortunately, owing to the gregariousness of the bugs, the badly stained cotton is usually brought to the gins in concentrated lots. The staining of the cotton by the cotton stainer means a loss of about one-half of its value when at its worst. Intermediate prices are brought for different degrees of damage.

Mr. Johnson, who is a member of the firm mentioned above and who has had considerable experience with the cotton stainer, has

[a] Bul. 33, Office Exp. Sta., p. 349; also Farmers' Bul. 47, p. 30, 1896.

[b] Rep. Fla. Agr. Exp. Sta. for fiscal year ending June 30, 1905, p. 27.

found that this insect can be controlled satisfactorily by destroying by hand whenever incipient colonies are found. From the time that the first bolls set until the cotton is picked a cotton grower should keep a close watch for the appearance of the pest and destroy the colonies whenever discovered. Weeds of all kinds and particularly the Spanish cocklebur should either not be permitted to grow in the vicinity of cotton fields or be kept under close surveillance in order that they may be promptly destroyed if the necessity arises.

METHODS OF CONTROL FOR GENERAL APPLICATION.

FARM PRACTICE AND CULTURAL METHODS.

In this country a single species of the plant-bugs dealt with in the foregoing pages rarely demands special treatment, while the combined attack of several, each occurring in moderate numbers, is often of vital importance in the determination of profit or loss to the cotton grower, and for this reason control methods which are generally effective against the various species are of great usefulness.

The cotton boll weevil is gradually revolutionizing the cotton-growing industry in the South, and in addition to making necessary certain modifications of the time-honored methods of cotton production, designed to avoid weevil damage as far as possible, has brought into prominence the several minor cotton pests which now demand intelligent attention. Fortunately the cultural methods for the control of the weevil, designed and tested on a broad scale in the course of the investigations of the Bureau of Entomology, and afterwards administered, and to some extent modified in the light of subsequent work by the Bureau of Plant Industry, are also, in part, of importance in the control of many minor cotton pests, including plant-bugs.

In general, the plant-bugs which attack cotton bolls in the Southern States attain their greatest abundance in August and September, and consequently the earliest maturing cotton suffers the least. The problem of producing an early maturing cotton crop has been one of the more important subjects of investigation in connection with the study of the control methods for use against the boll weevil. This has been considered from an entomological standpoint and put into the form of definite practical recommendations by Mr. W. D. Hunter, in Farmers' Bulletins [a] and in circulars dealing with the boll weevil. Of more importance in the control of the weevil is the destruction in the fall of cotton plants in the field. This practice is, of course, particularly effective as a measure against the boll weevil, which has no other food plant than cotton, but many plant-

[a] Farmers' Bulletins 163, 189, 216, and 344, U. S. Dept. Agriculture.

bugs are doubtless eradicated by the methods of destruction of cotton stalks advocated by the Bureau of Entomology, i. e., by piling in windrows and burning. In addition to the direct destruction of the insects, many nymphs would fail to reach maturity in a well-cleared field, and the adults would be deprived of favorable conditions for hibernation offered by cotton plants left standing in the fields during the winter.

Associated with these methods, and probably of equal importance, is the practice of destroying early in the season wild food plants of the plant-bugs which attack cotton, thus checking the multiplication of the insects which later turn their attention to the cotton bolls. The wide range of food plants known for nearly all the species dealt with in this bulletin indicates the strong advisability of clean cultivation and the prevention of the growth of weeds along fences and roadsides close to cotton fields.

DIRECT METHODS OF COMBATING PLANT-BUGS IN COTTON FIELDS.

Under certain circumstances contact insecticides may be of use against plant-bugs in cotton fields, but only when they occur in such excessive abundance that all methods of collecting are impractical. Kerosene emulsion will probably prove the most effective spray, but before using on a large scale preliminary tests should be made to determine the required strength.

Hand-picking of the conchuela has already been discussed and detailed information regarding this measure given. The good results obtained by the use of this method of control against the cotton stainer or "red bug" in Florida have also been referred to. This is in many cases the only practical method of protecting the cotton crop against severe injury. Its success is dependent for the most part on the size and conspicuousness of the species dealt with and on the efficiency with which the work of the pickers is supervised. The foregoing detailed discussion of the destructive capabilities of plant-bugs indicates the amount which a cotton planter can afford to invest in hand-picking. The season of the year must be taken into consideration in the estimation of this point. In general, it may be said that in midsummer from 10 to 25 cents per hundred, according to the abundance of the pests,[a] or day labor at the rate of 50 cents to $1.25 per day is not too great an investment for collecting the larger species of plant-bugs which may be found attacking cotton bolls. Such expenditures, judiciously made, will undoubtedly result in saving from destruction

[a] The scarcer the bugs the more one can afford to pay per 100 collected, owing to greater individual destructiveness heretofore explained.

cotton worth many times the outlay. It is not urged that all cotton growers begin a systematic search for the presence of bugs in their cotton fields, but there are known to be many whose experience has already shown the extent of the damage chargeable to plant-bugs. For them the investigations here reported should be useful in the determination as to whether or not remedial measures are desirable under their own peculiar conditions. It is hoped that the attention of many others will be directed to this damage where it has previously been unnoticed or, if noticed, misunderstood. By careful attention to the elimination, as far as practicable, of damage by these and other minor cotton pests, an important advance will be made toward the reestablishment of cotton growing upon the profitable basis existent before the advent of the cotton boll weevil.

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